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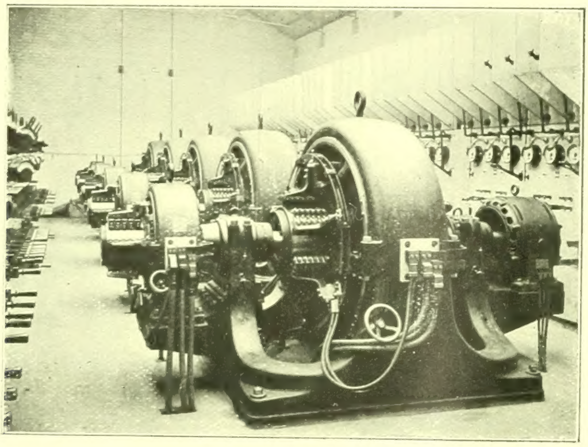

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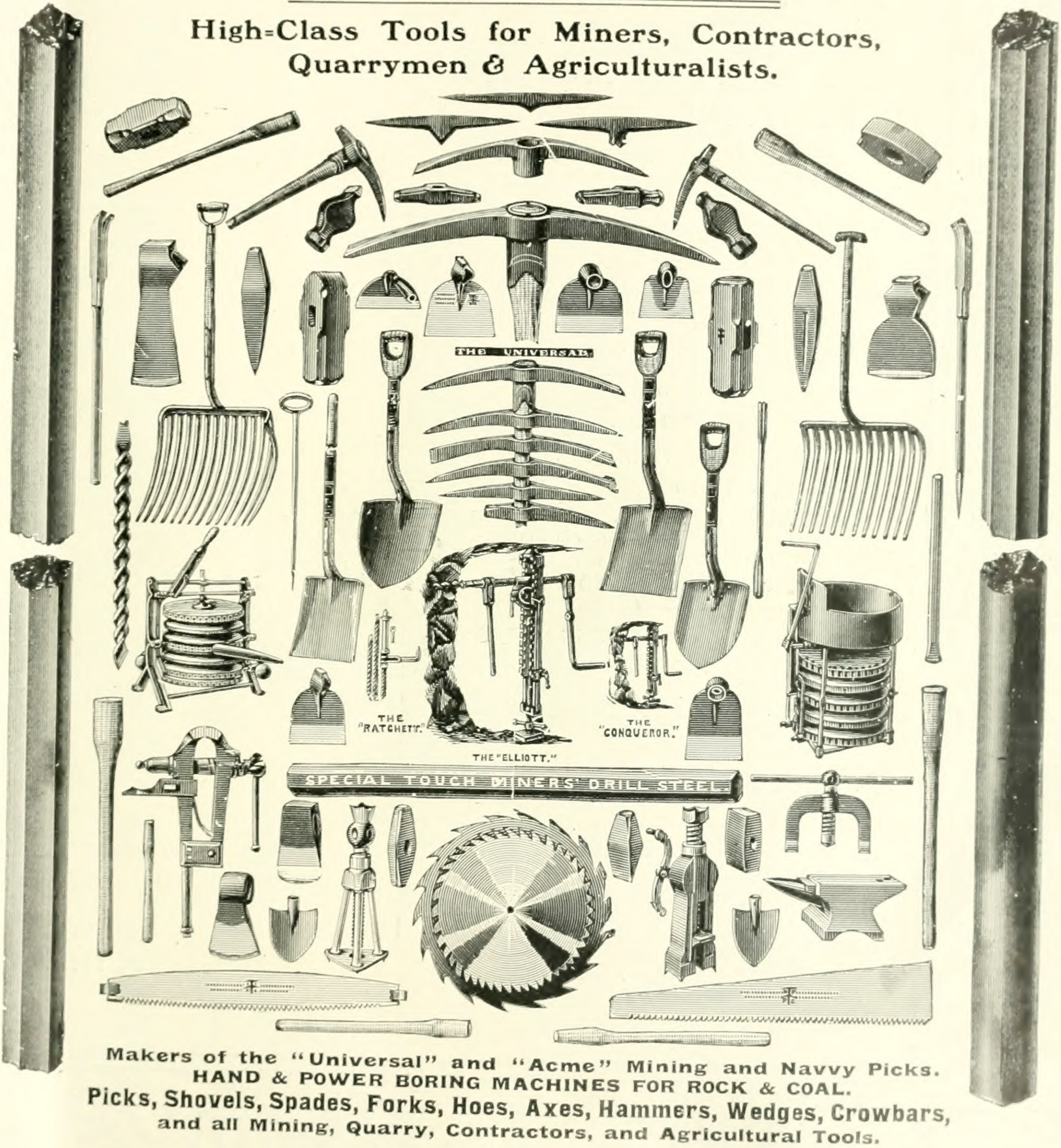
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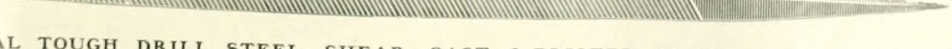

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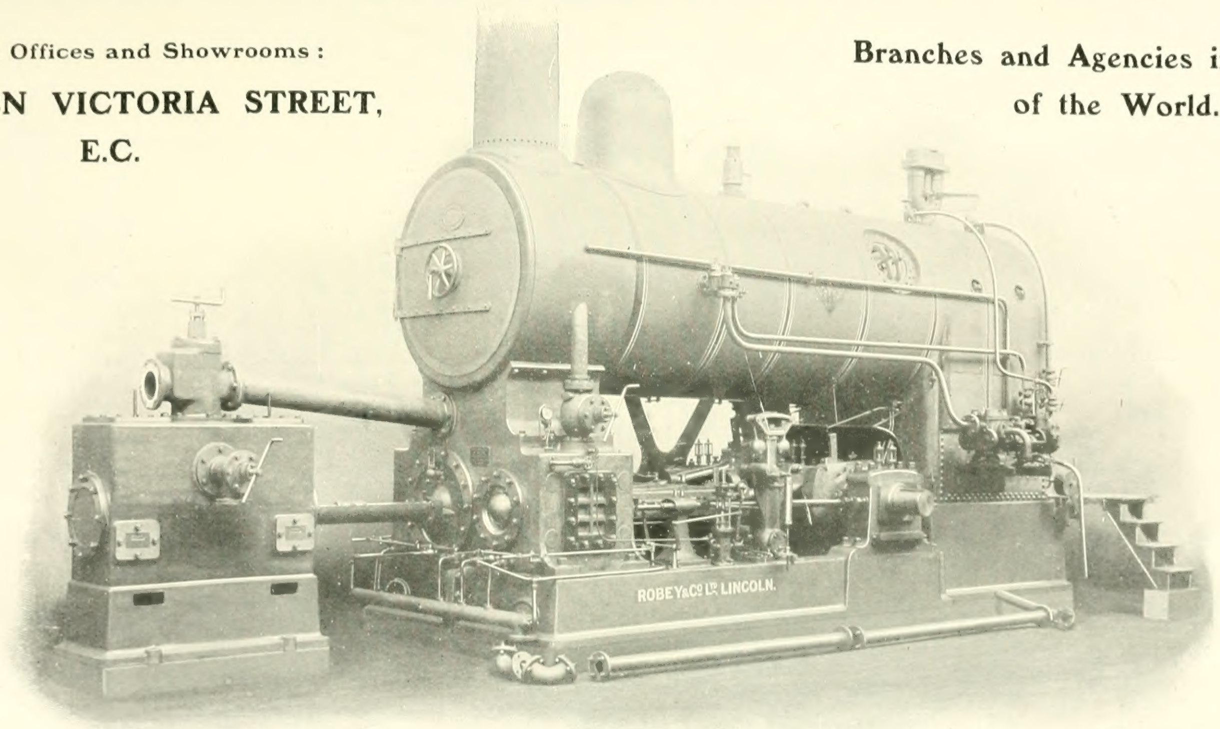

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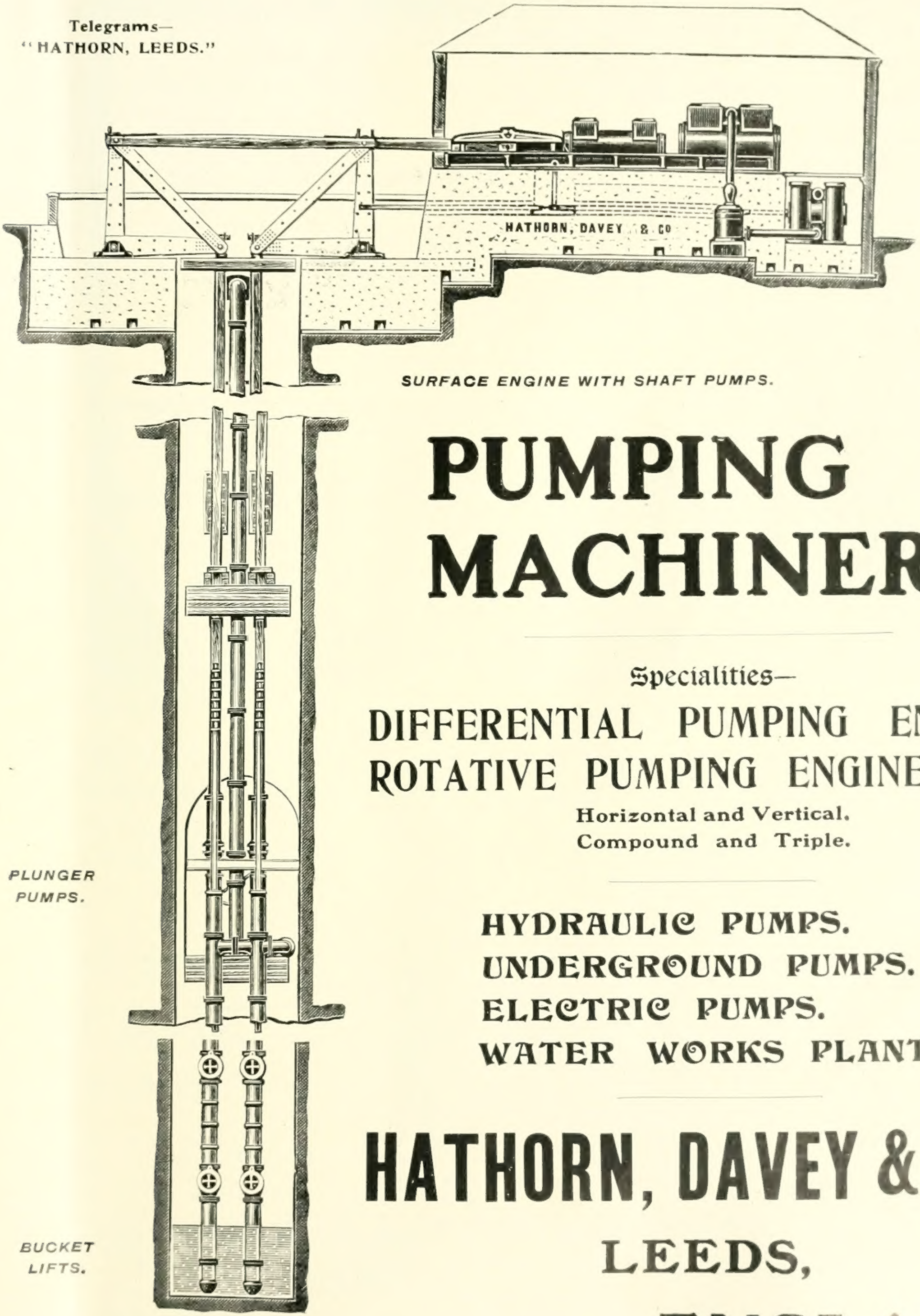

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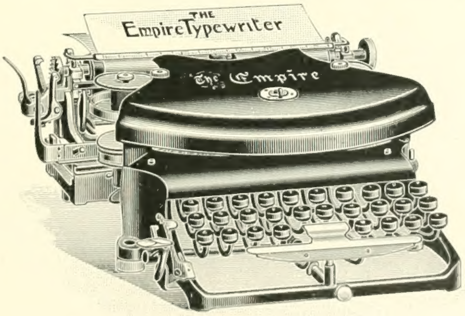

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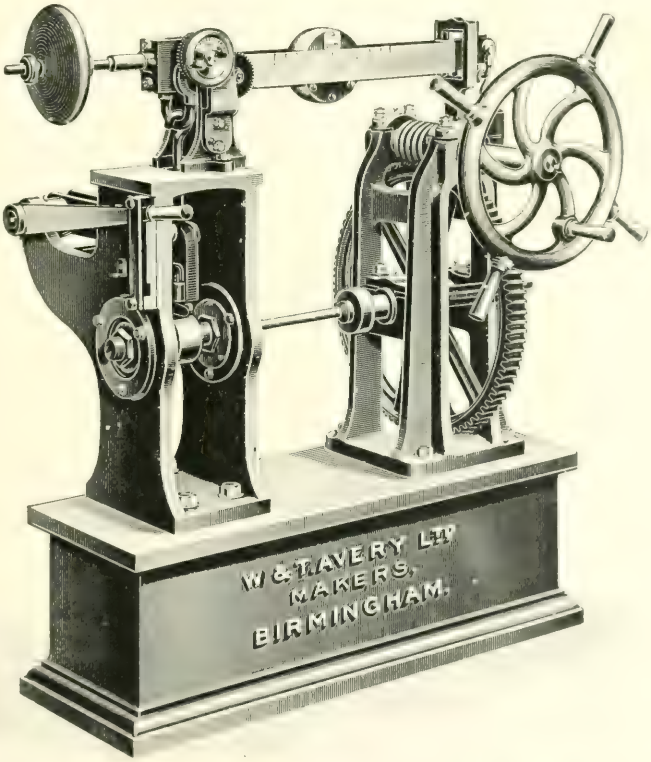

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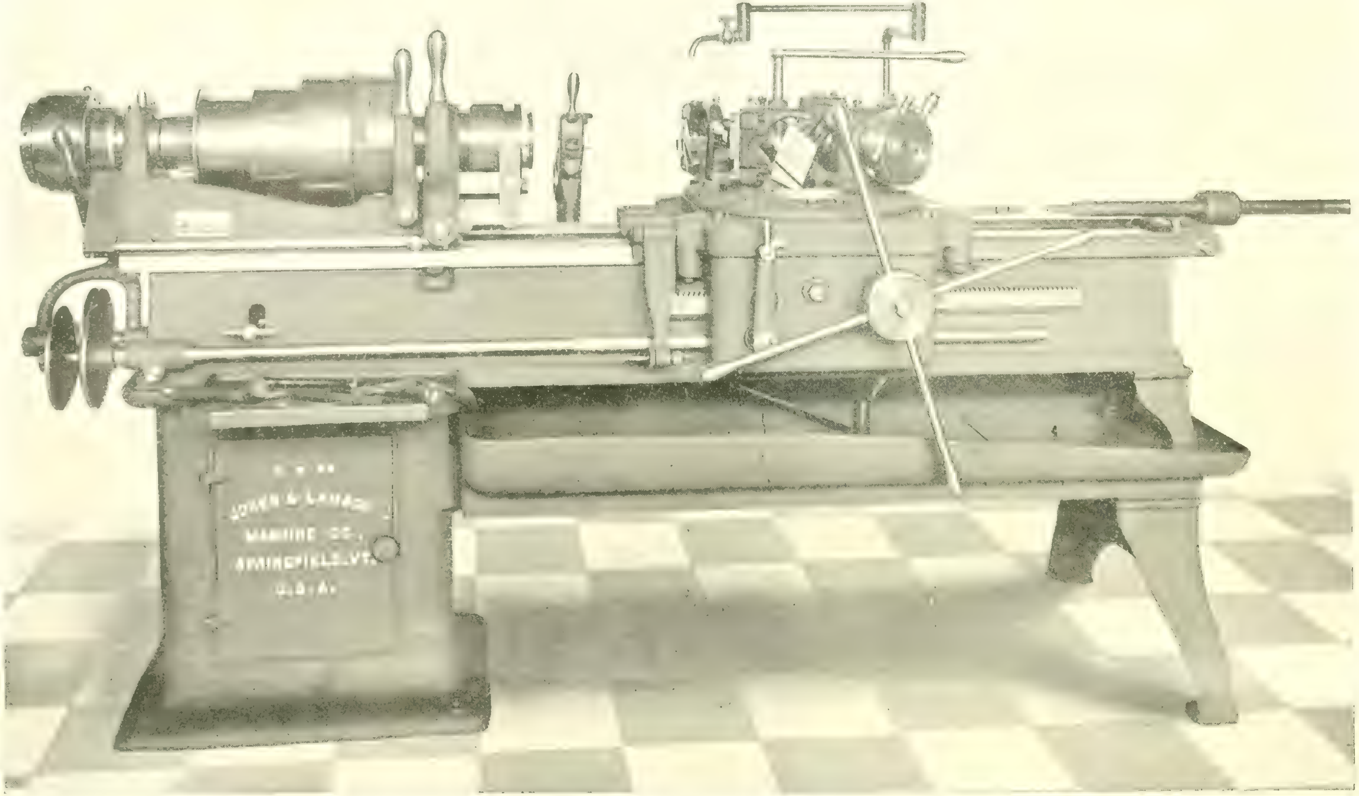

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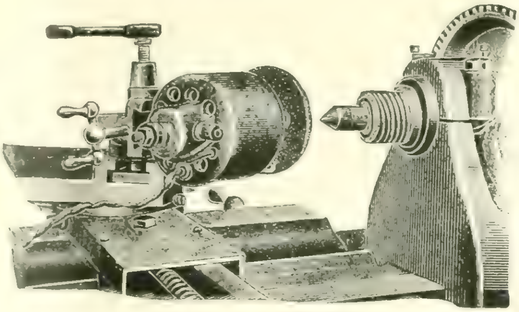

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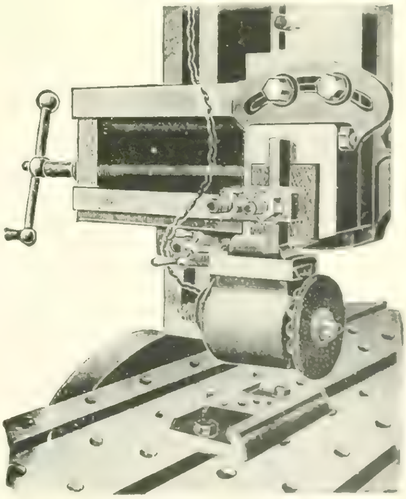

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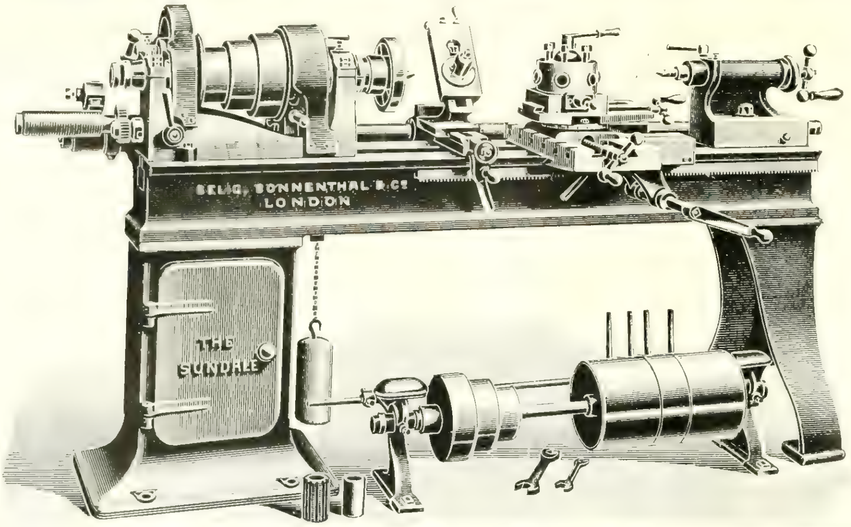

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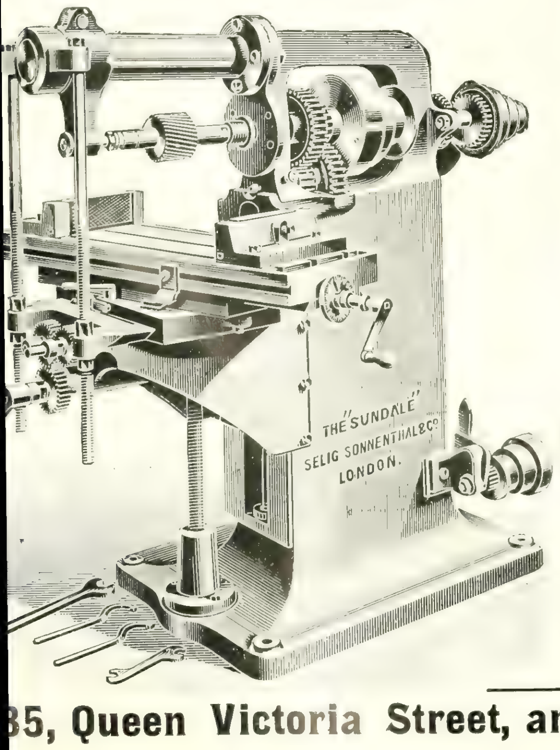

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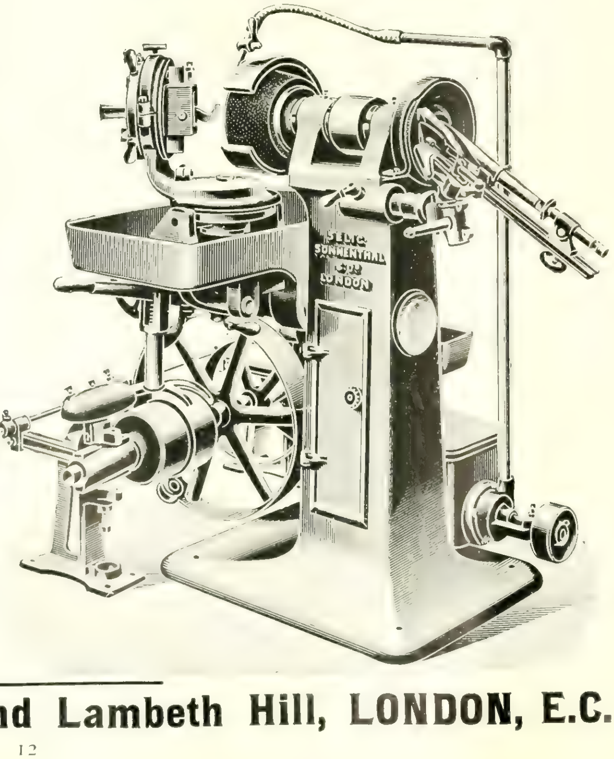

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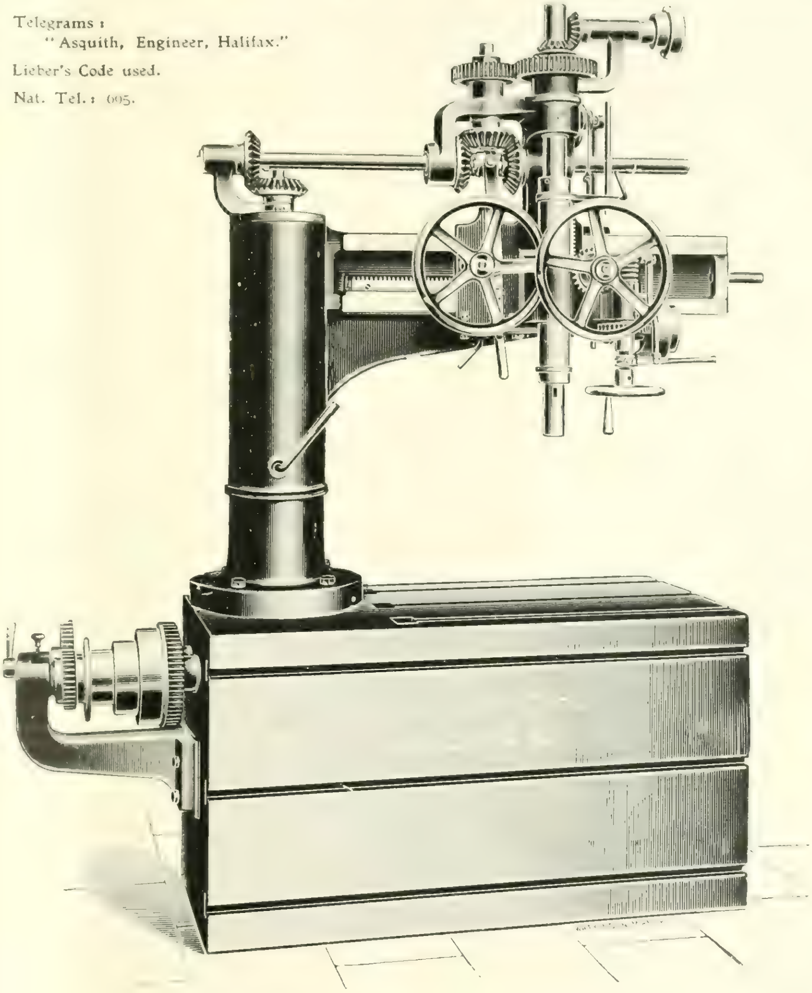

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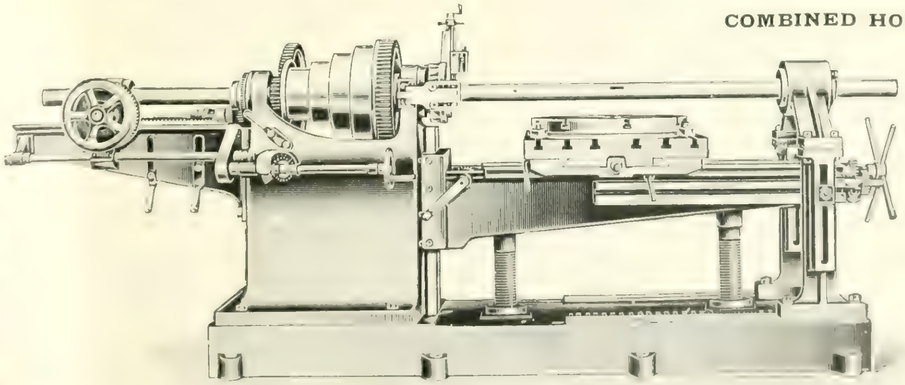

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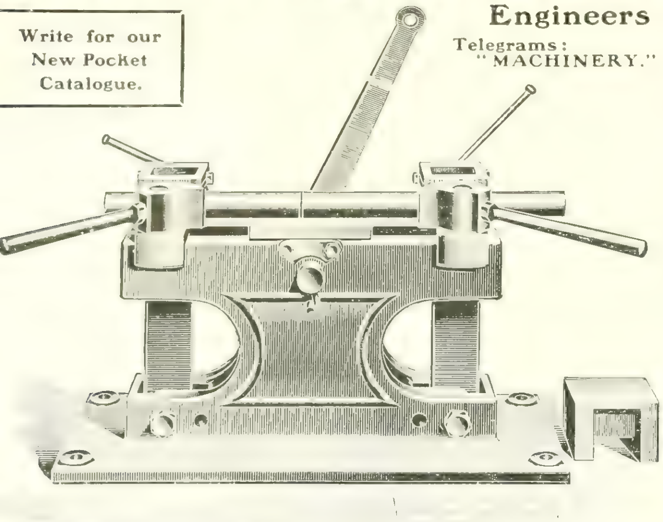

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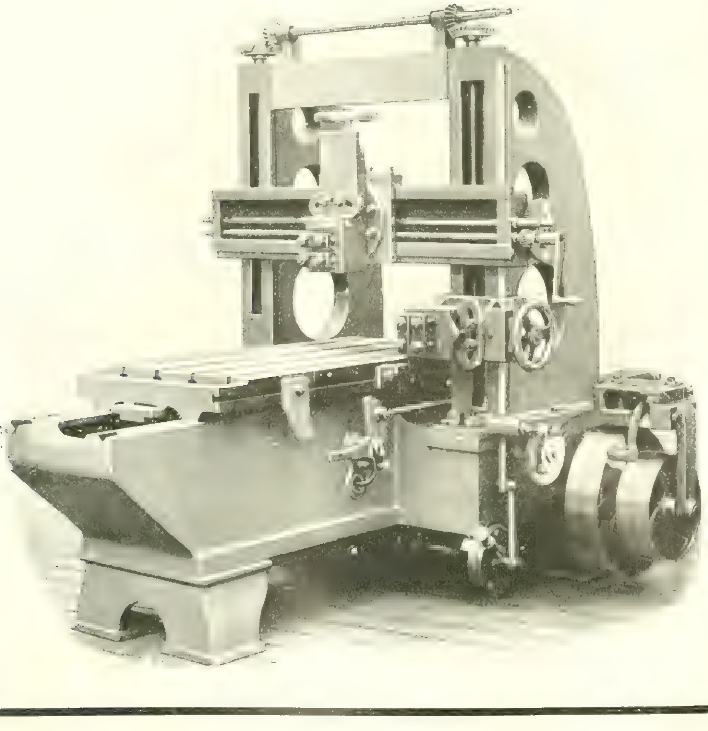

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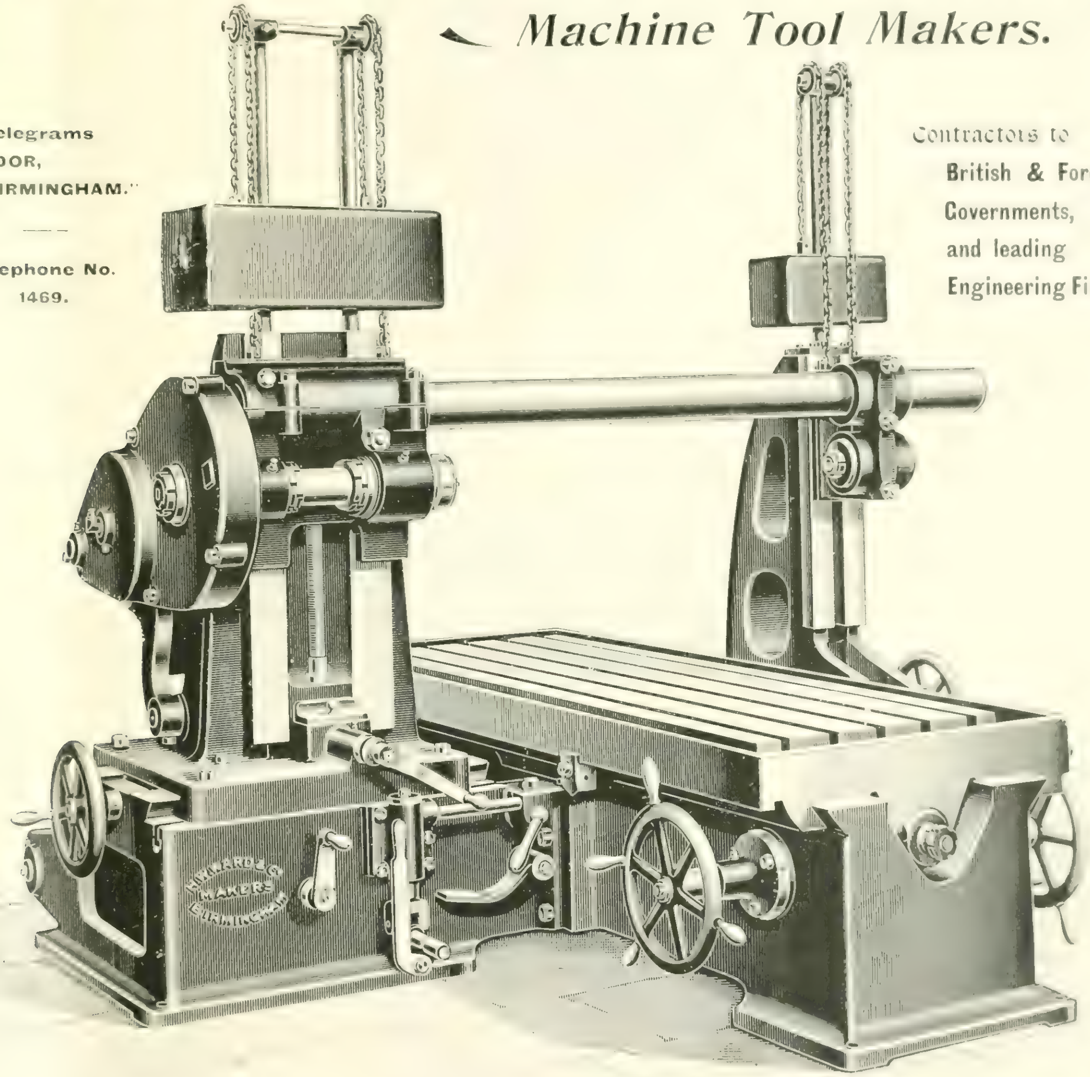

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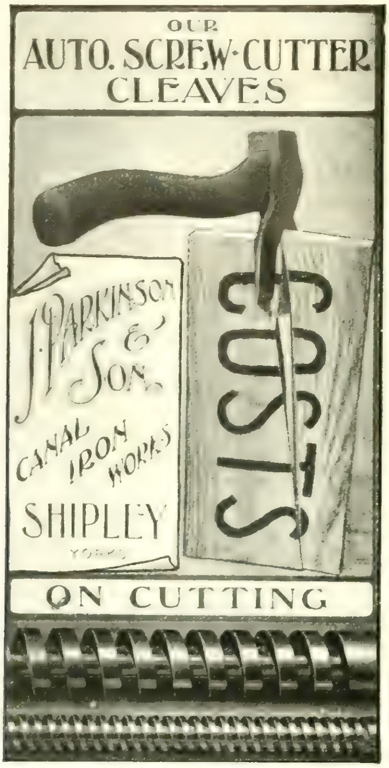

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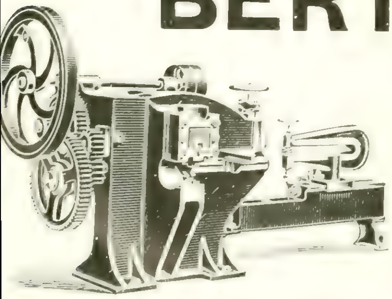

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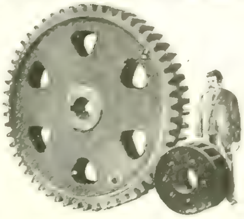

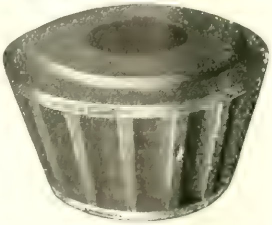

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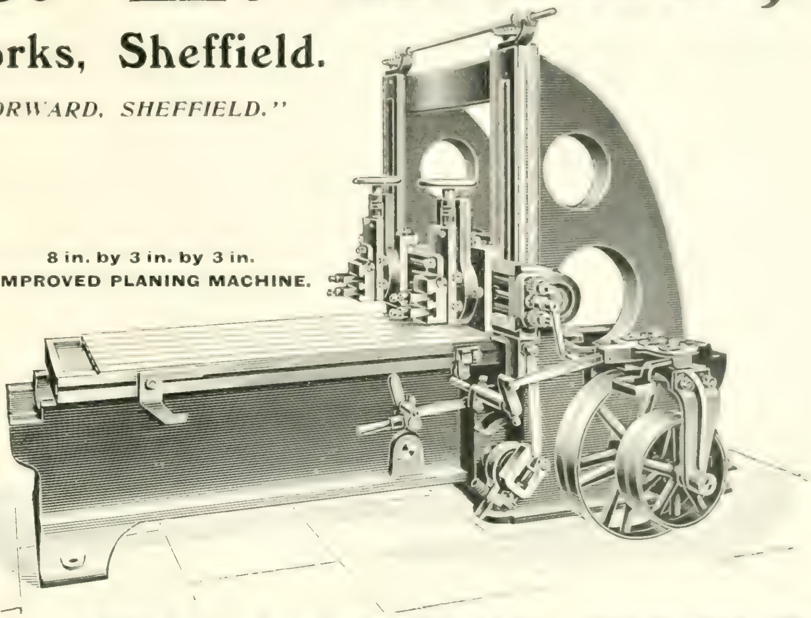

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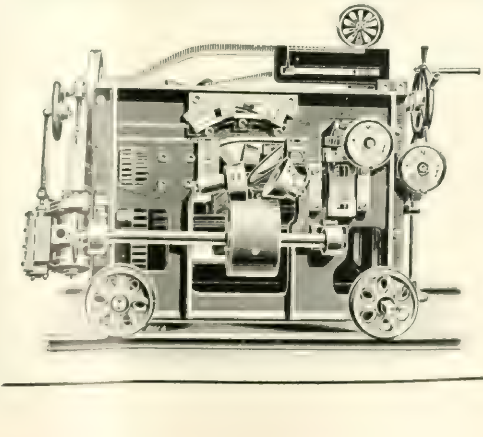

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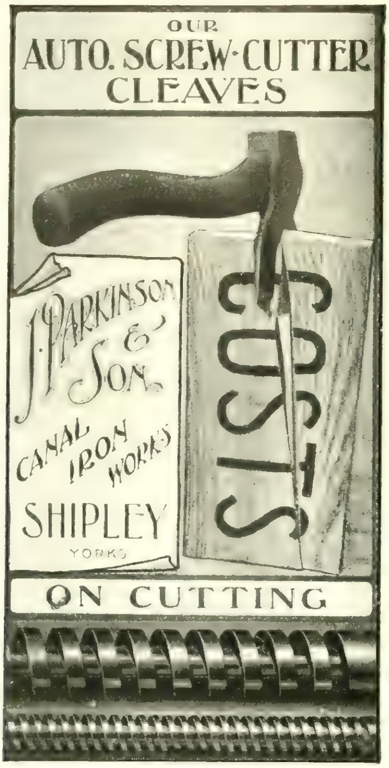
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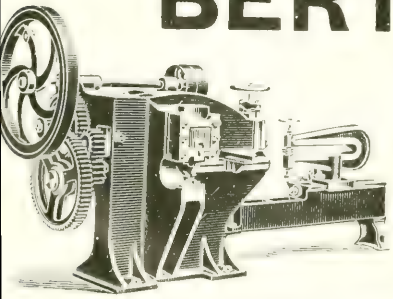
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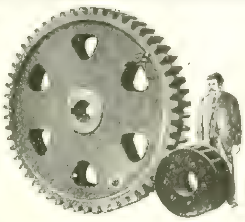

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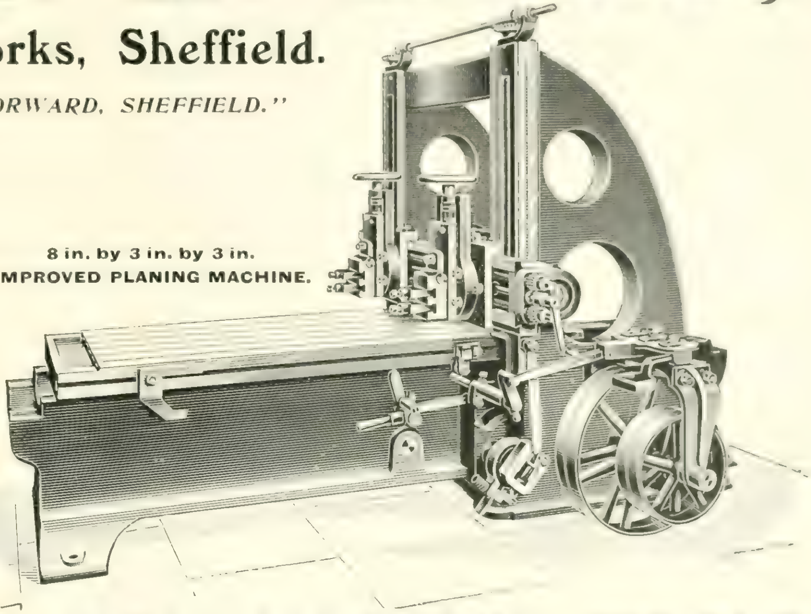

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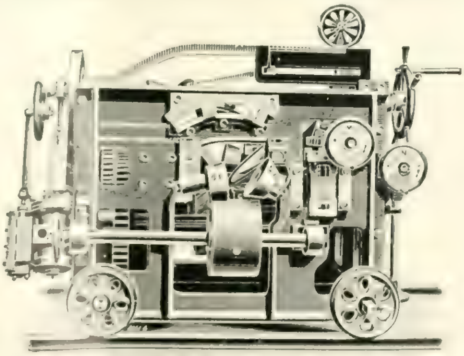

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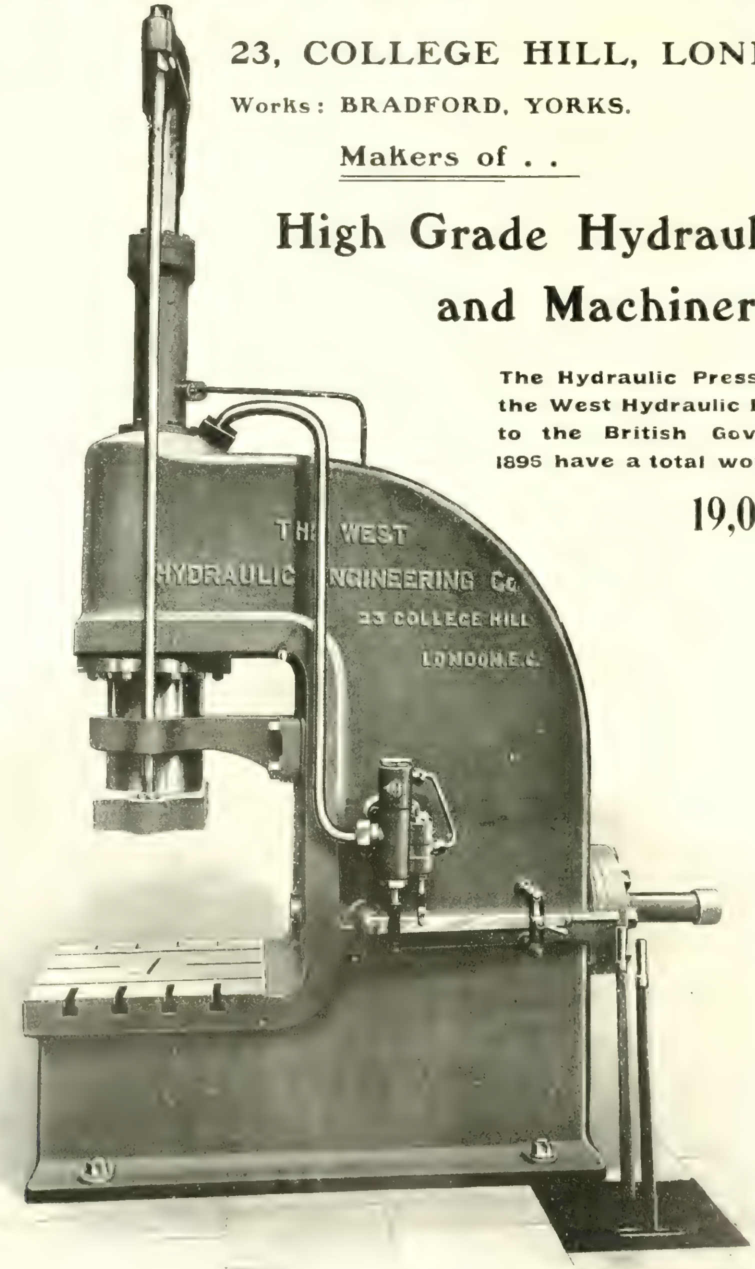

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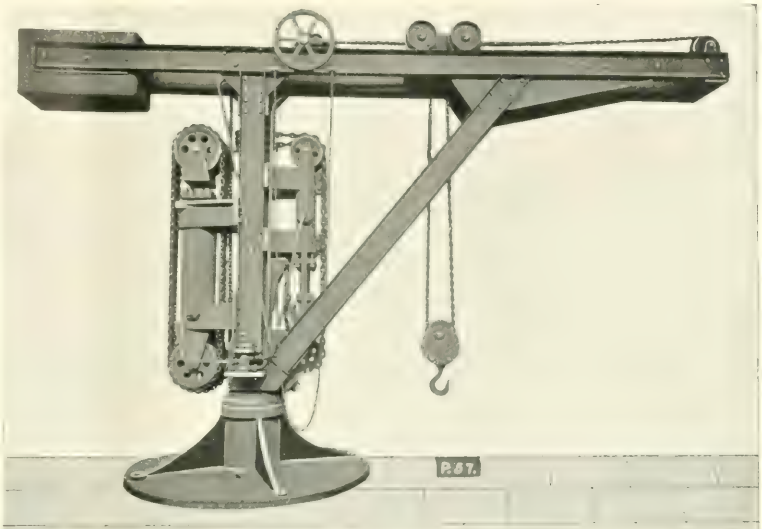

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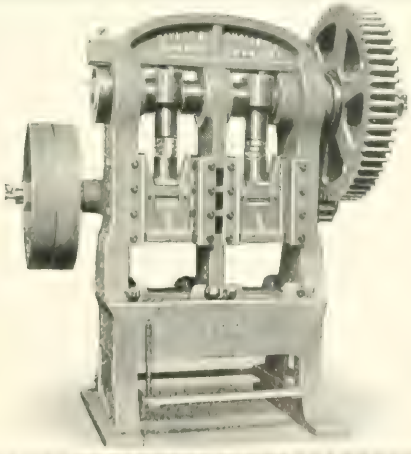

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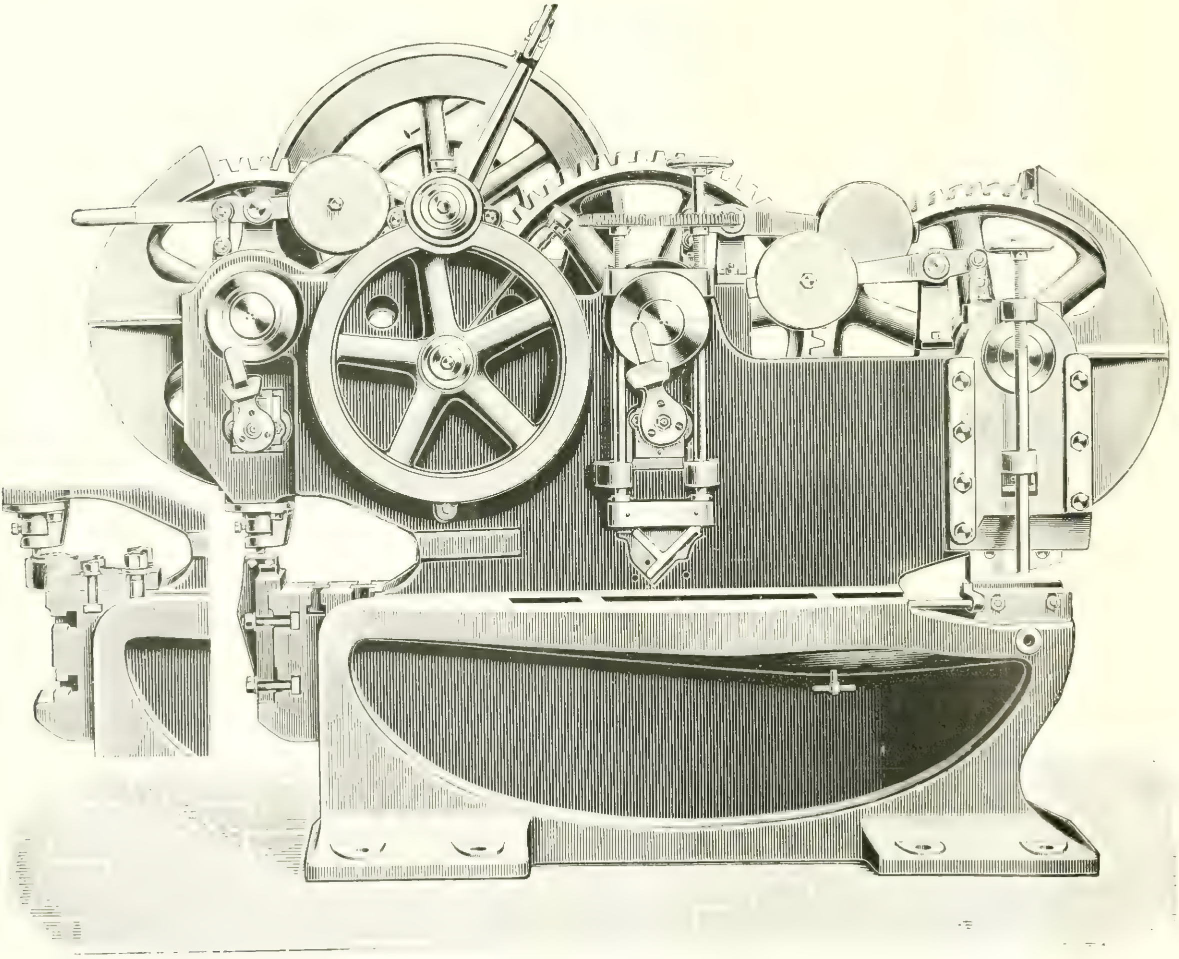

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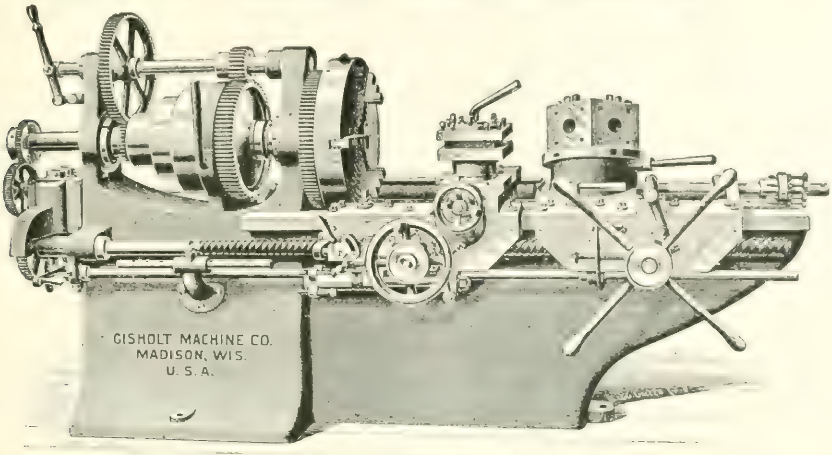
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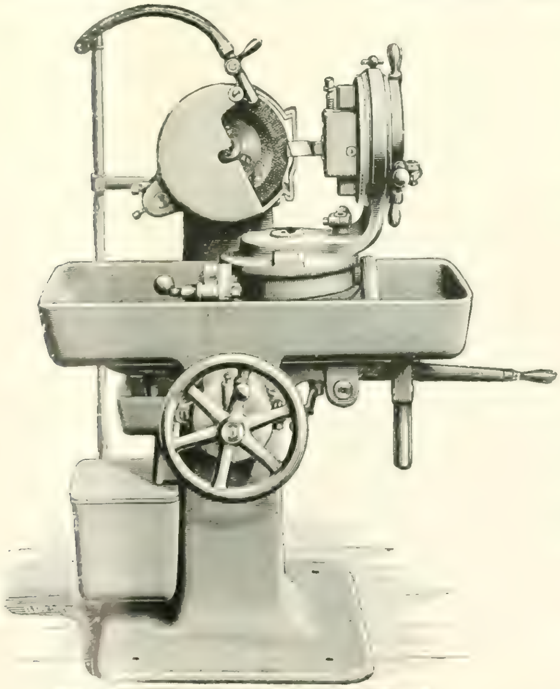

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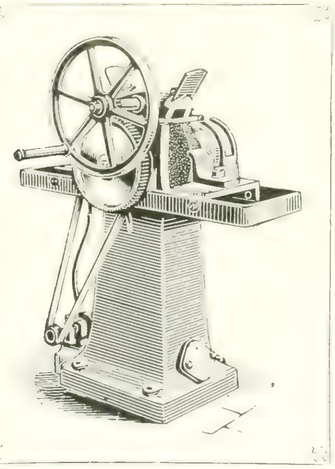

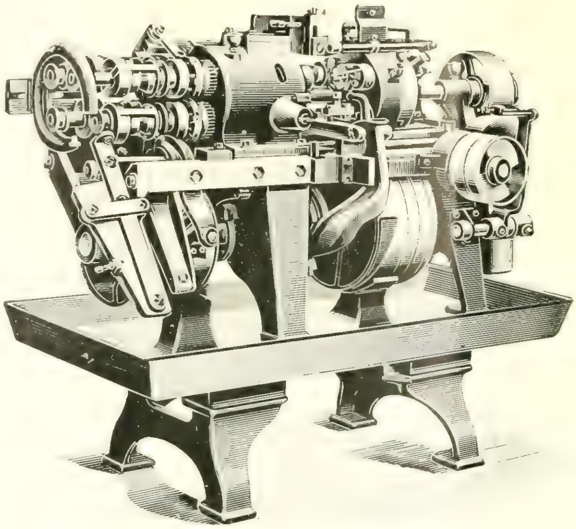

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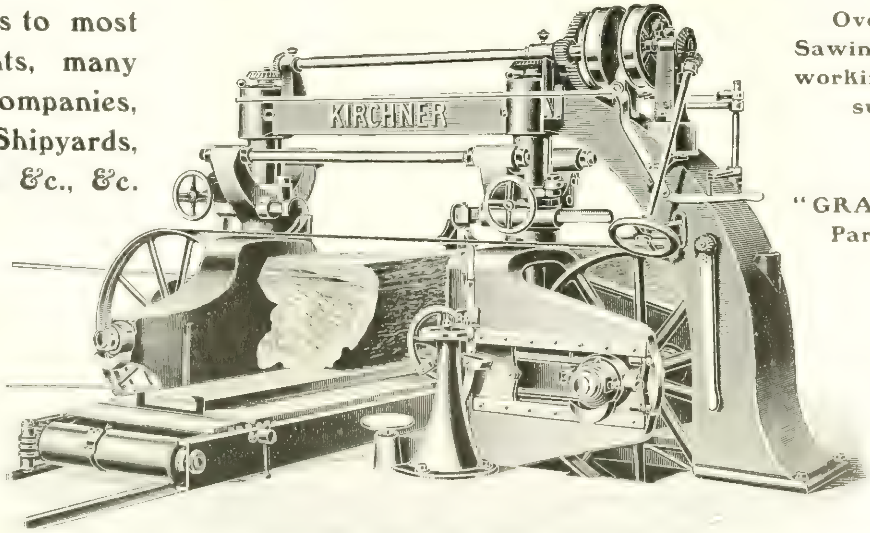

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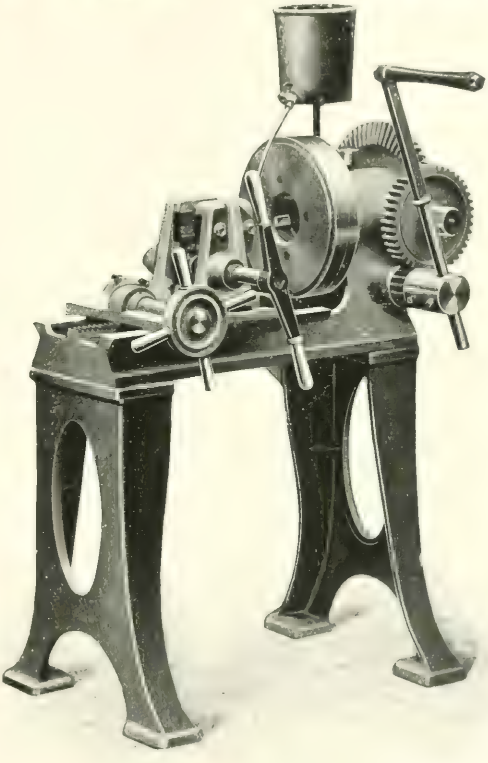

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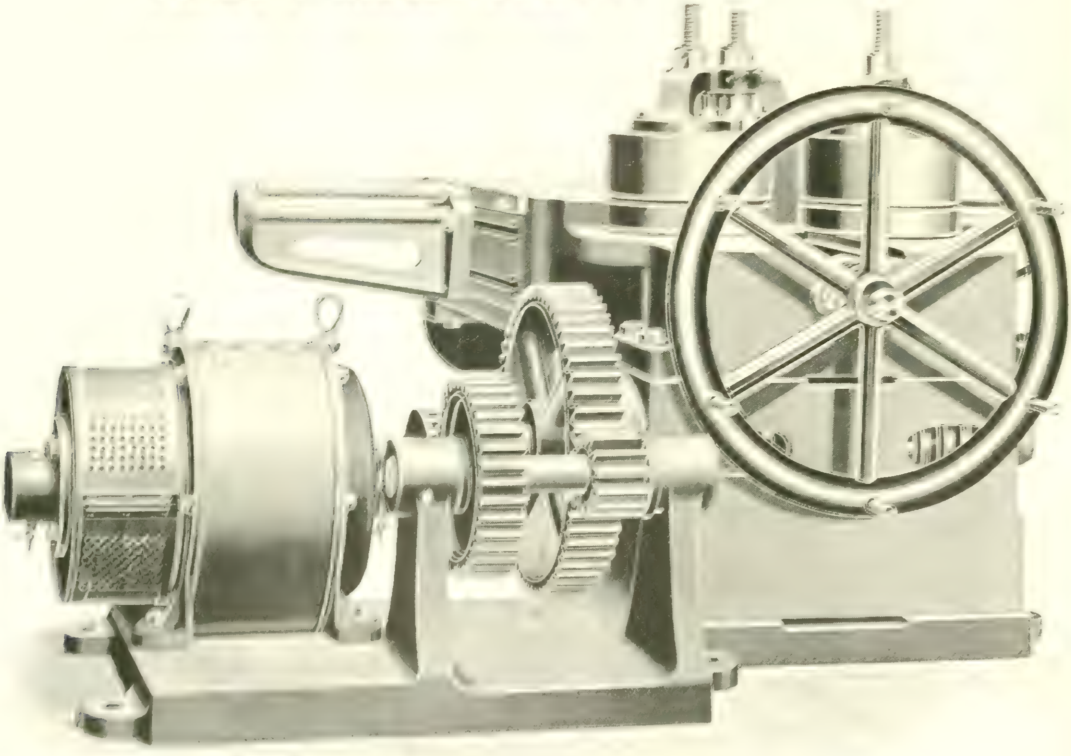

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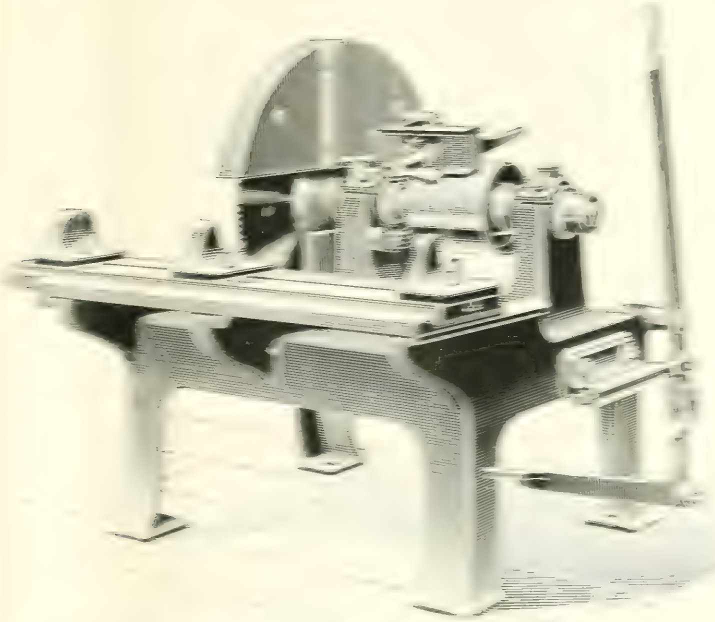

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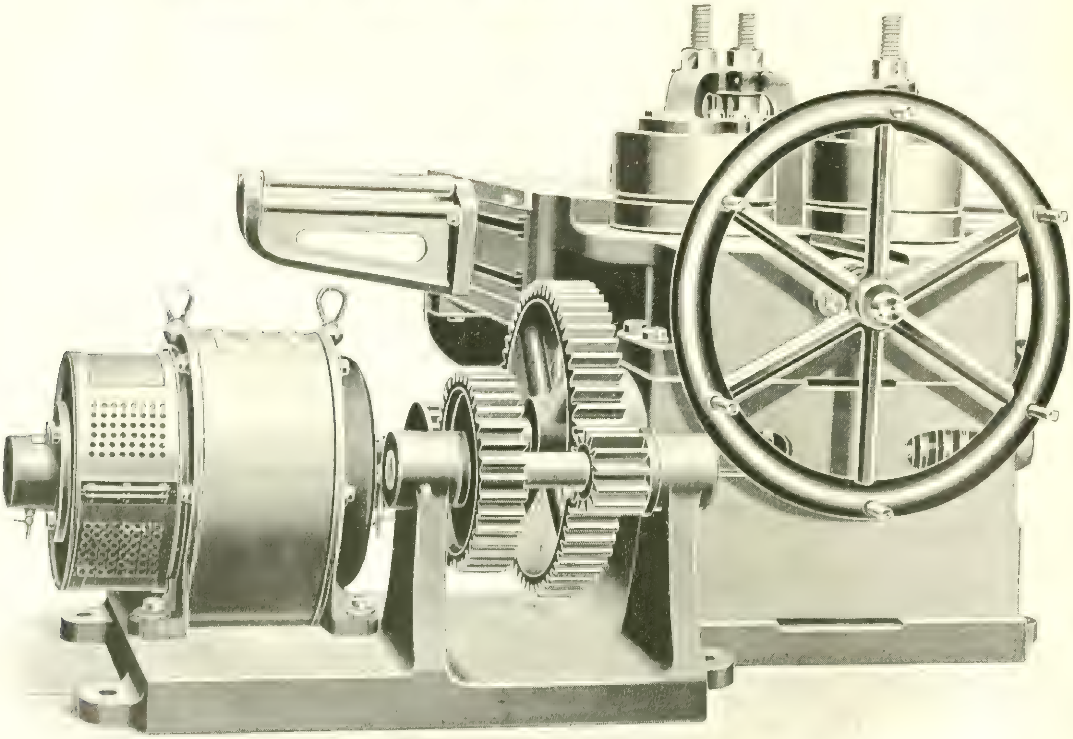

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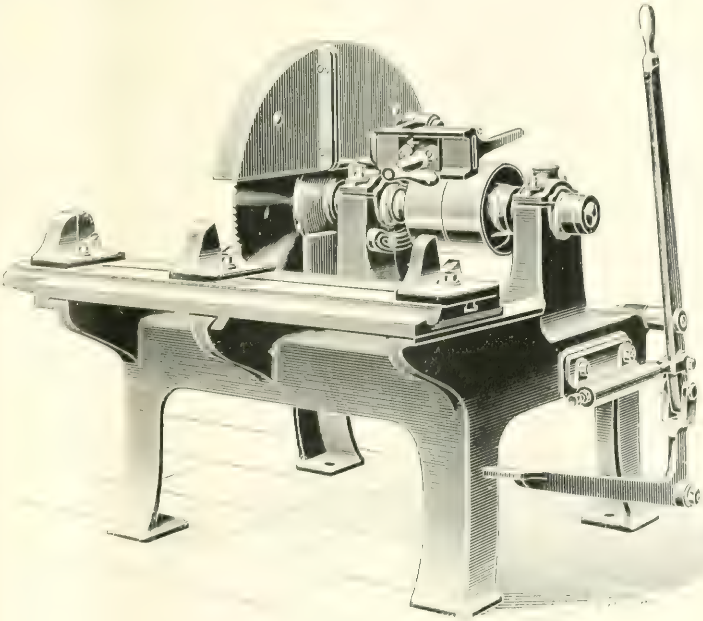

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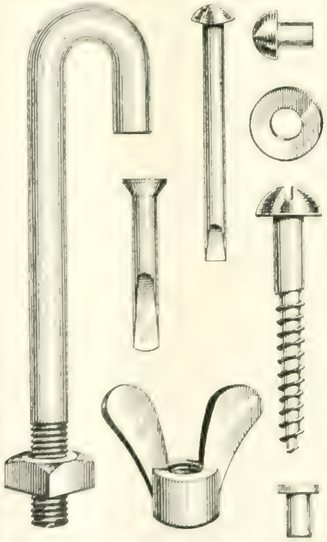

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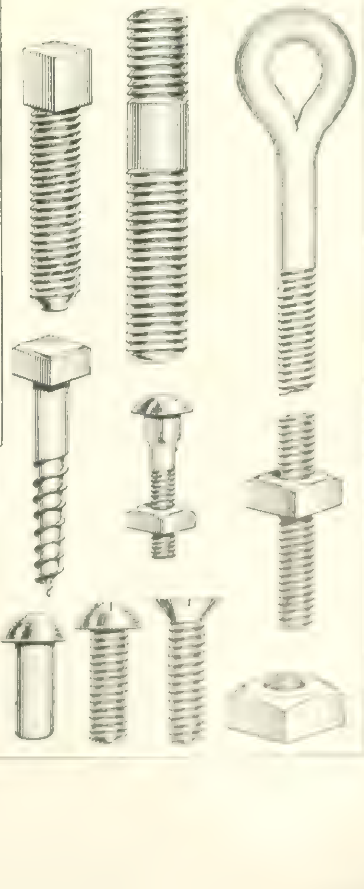

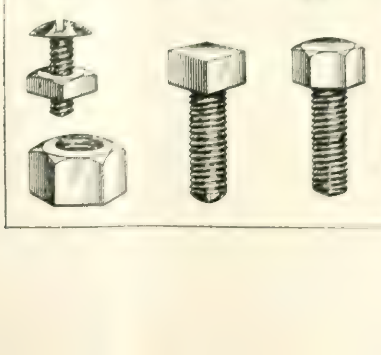

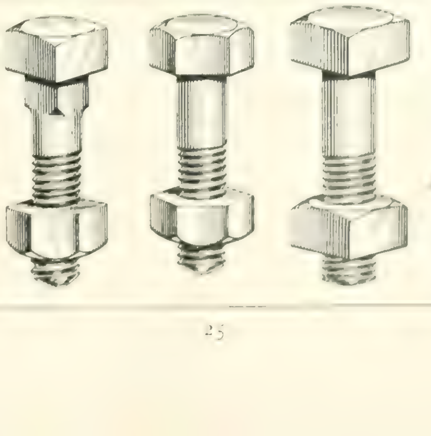

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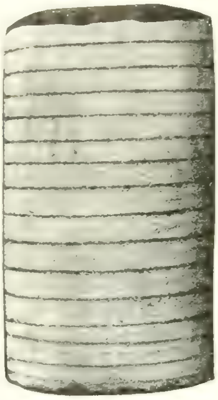

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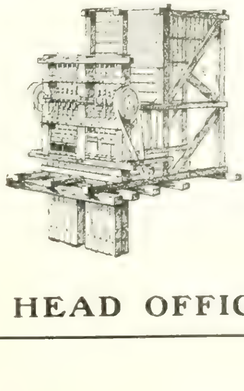

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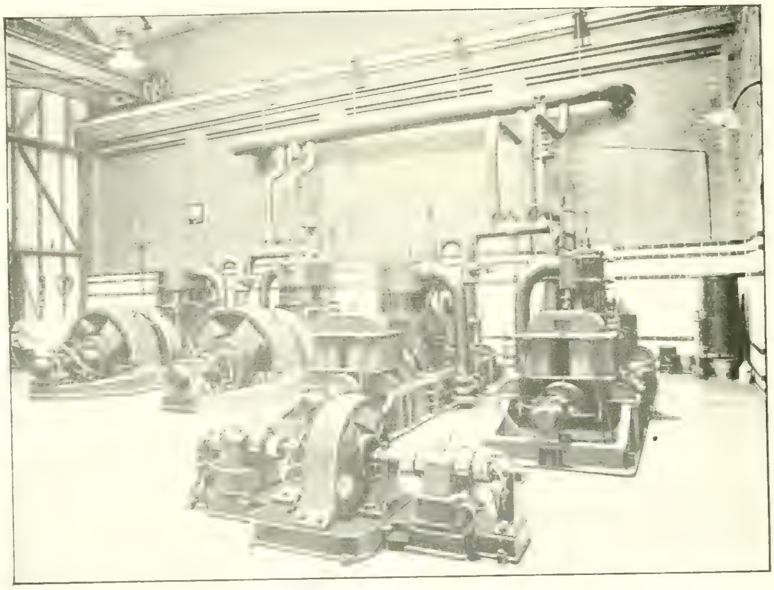

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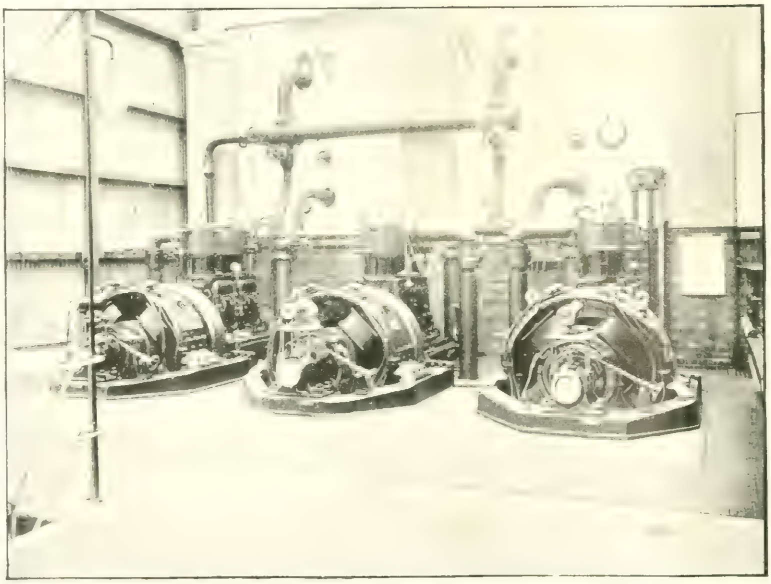

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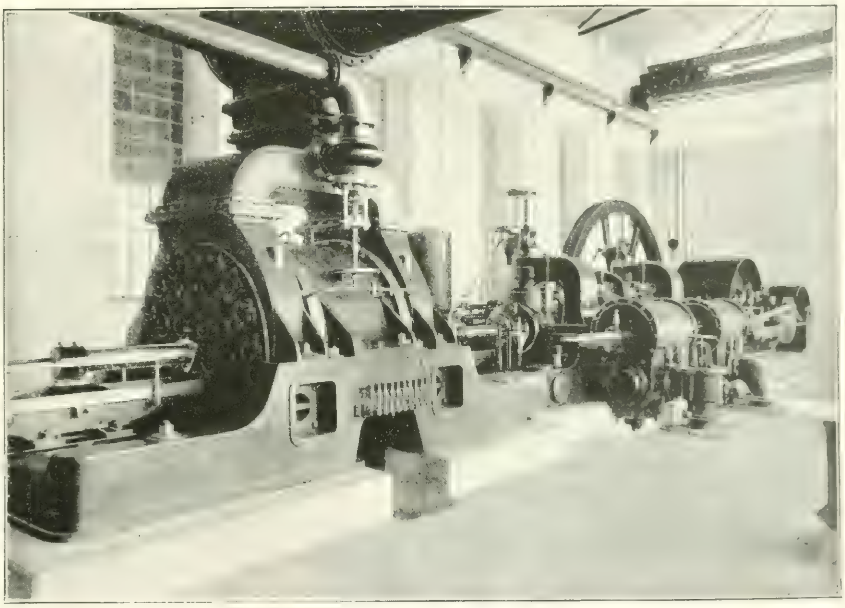

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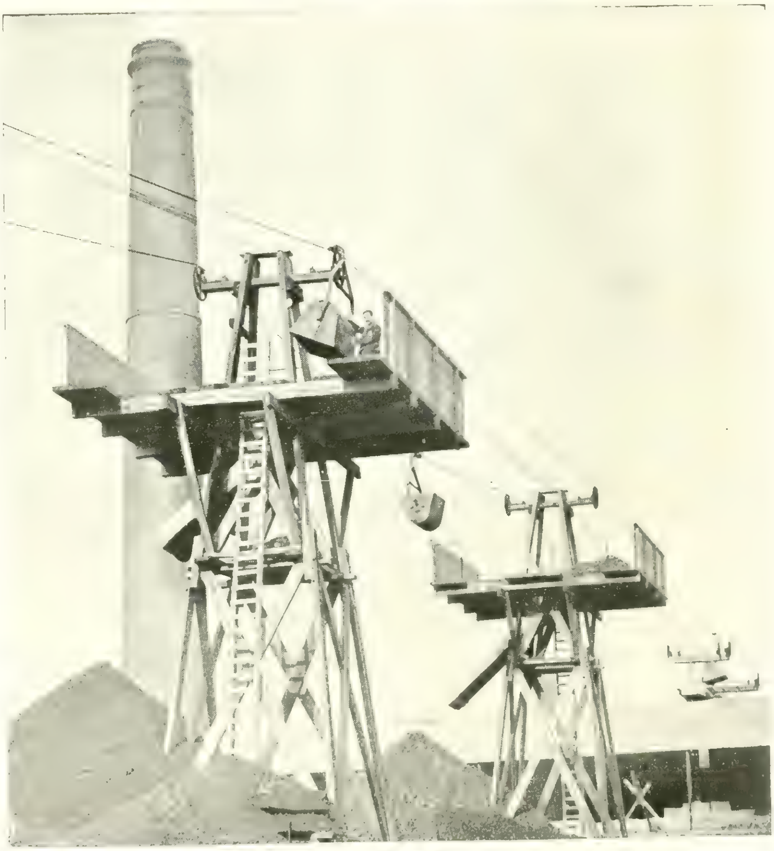

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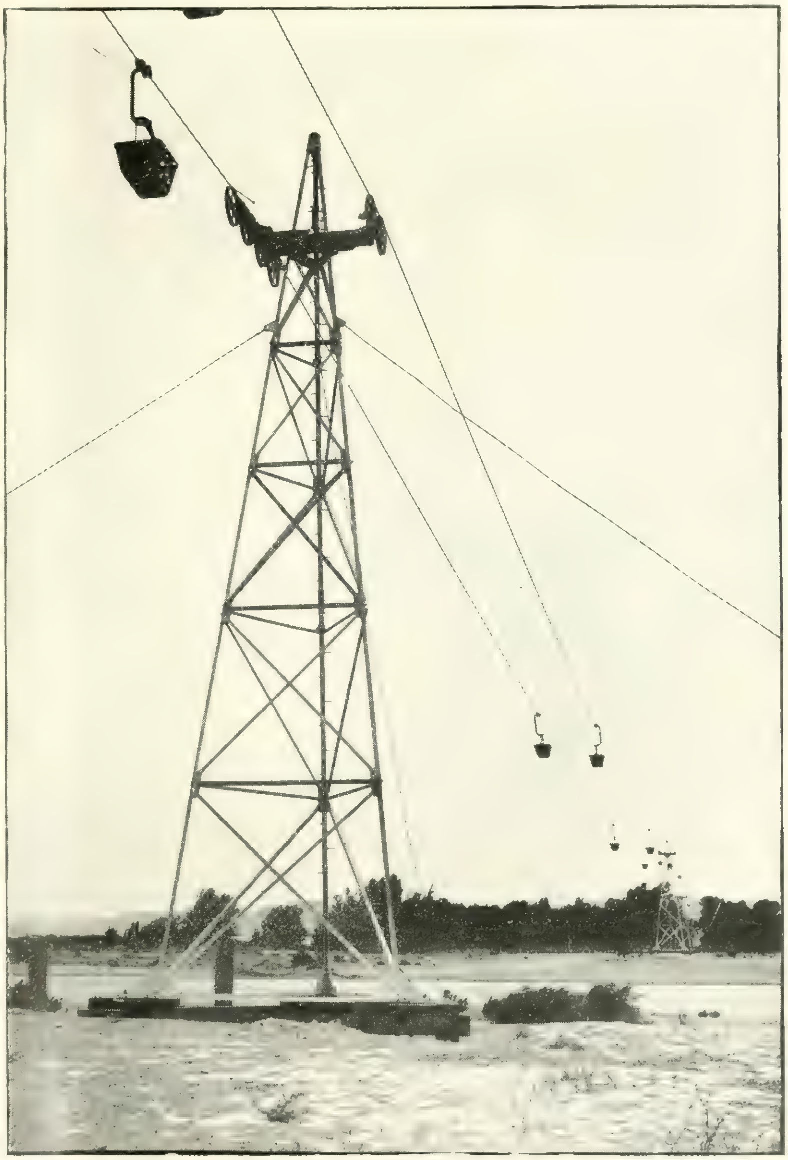

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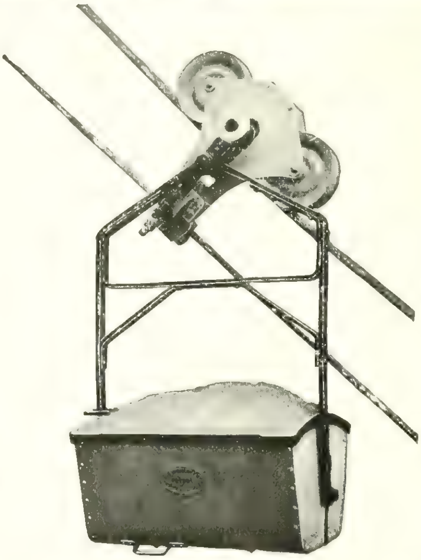

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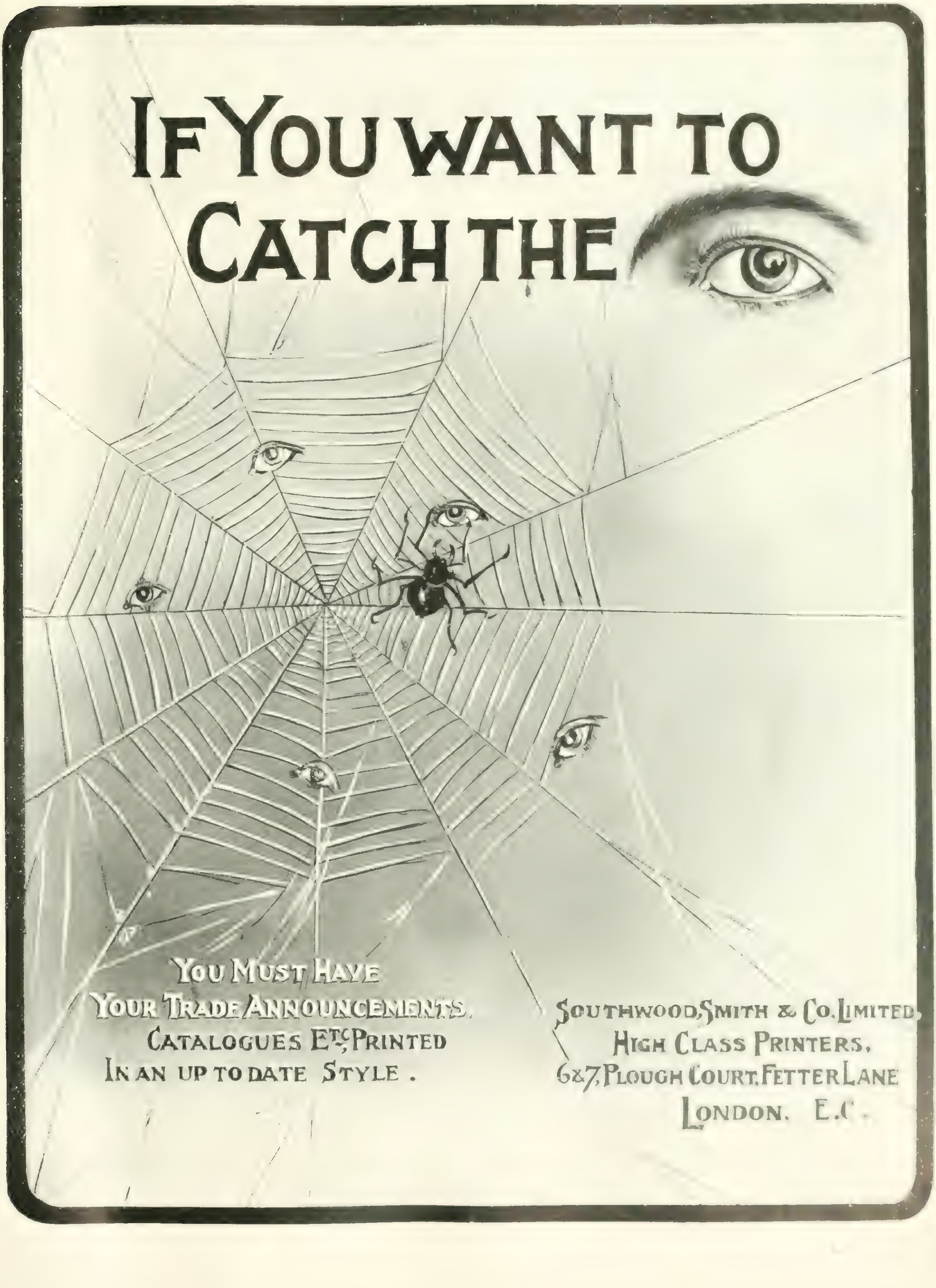

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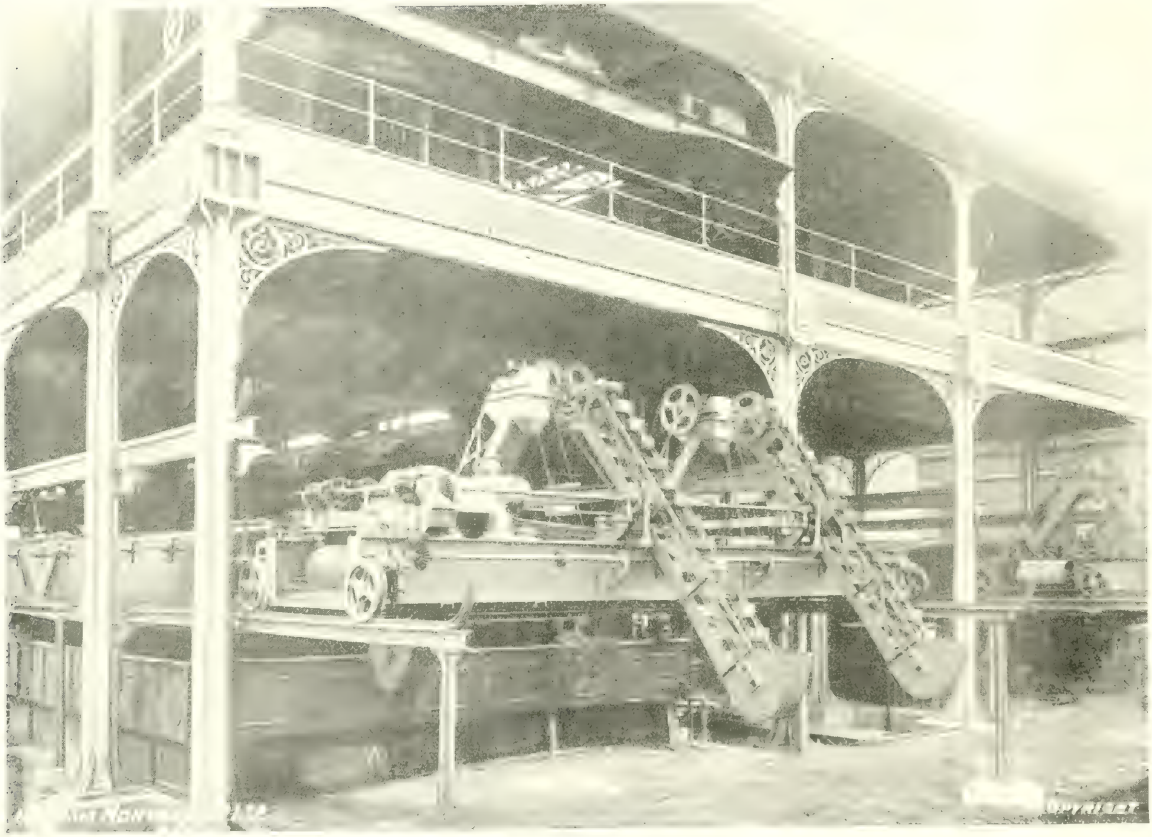

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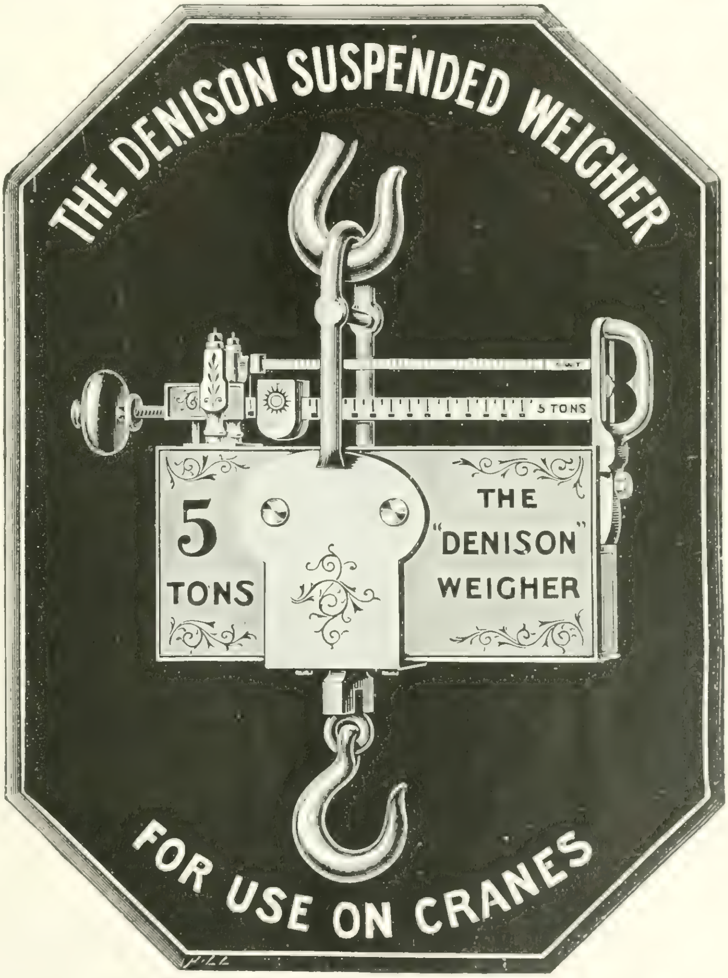

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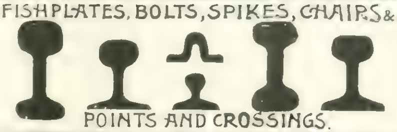

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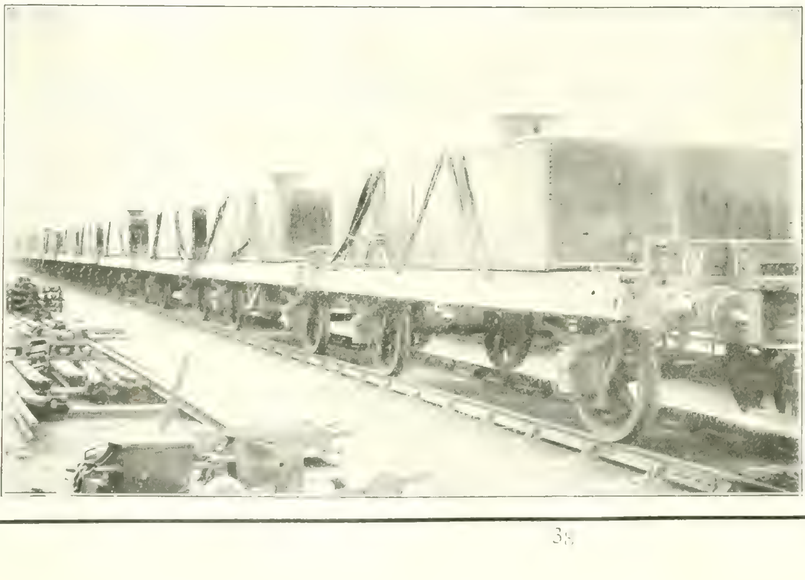

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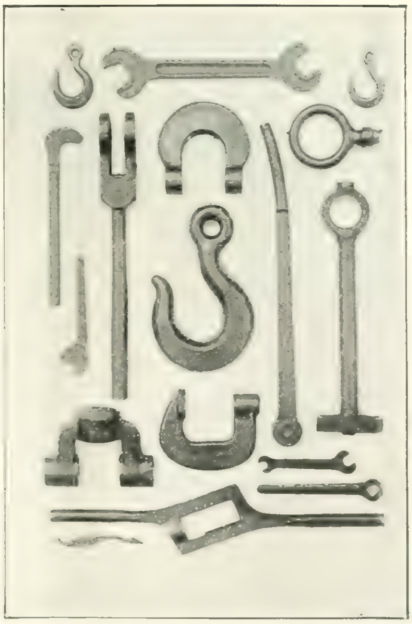

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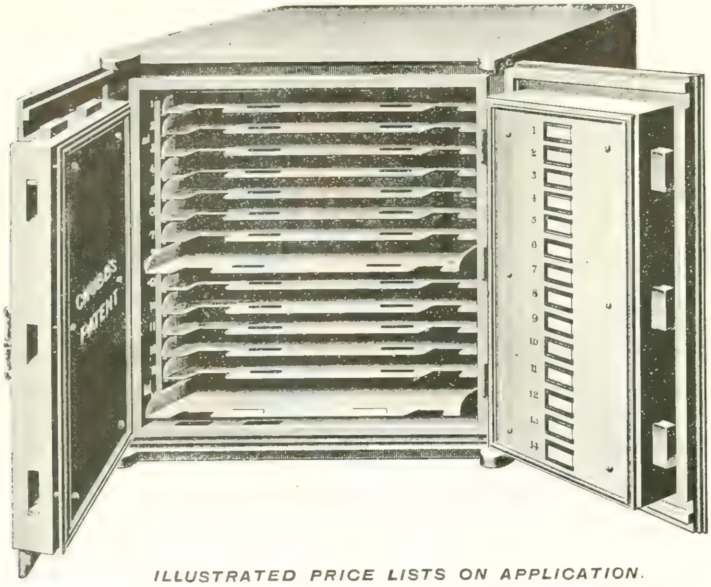

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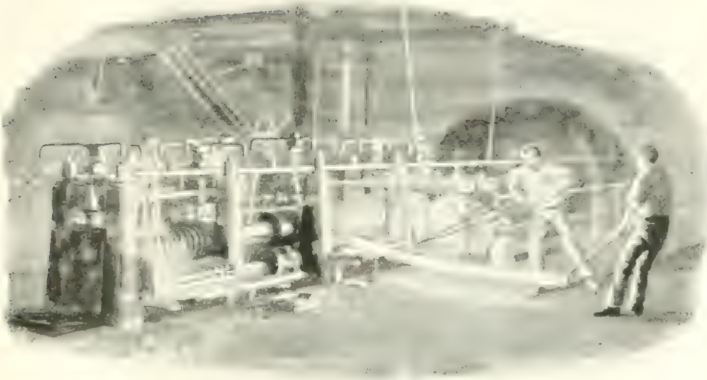

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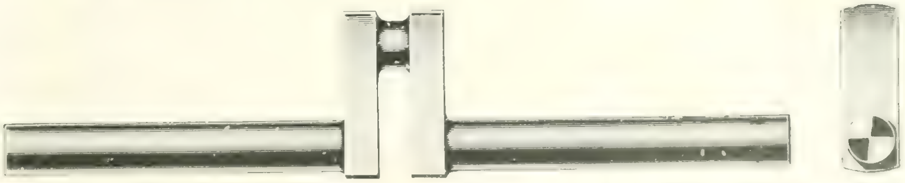

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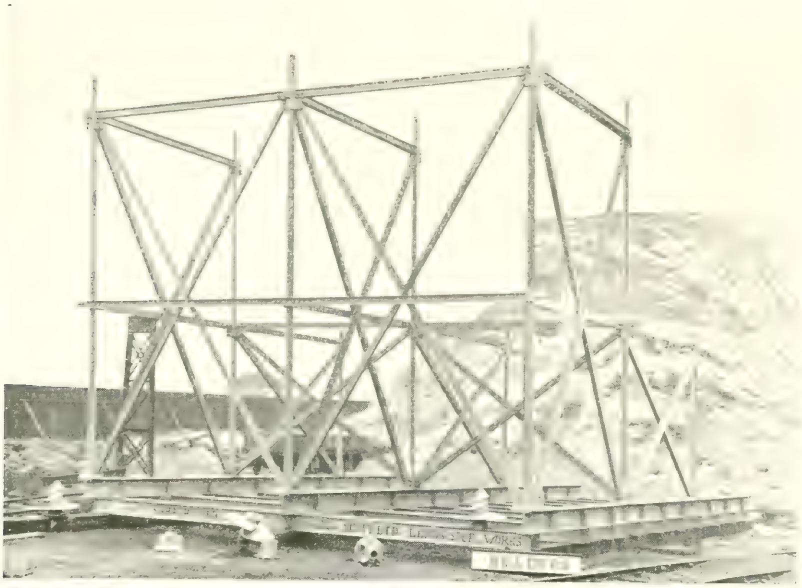

One section of the steel work, Karachi Pier, India, photographed upside down. The extension of the Pier for which we supplied the whole of the iron and steel work was 2045 feet in length, the weight of the material approximately being 2,000 tons.

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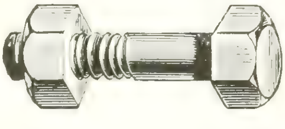

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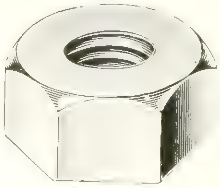

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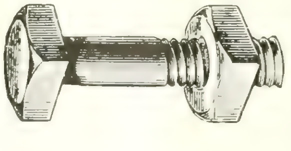

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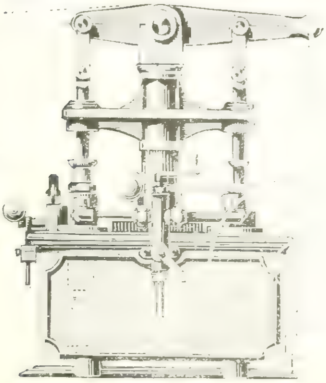

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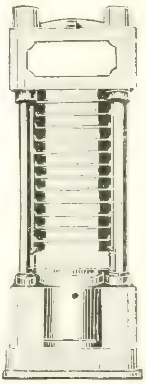

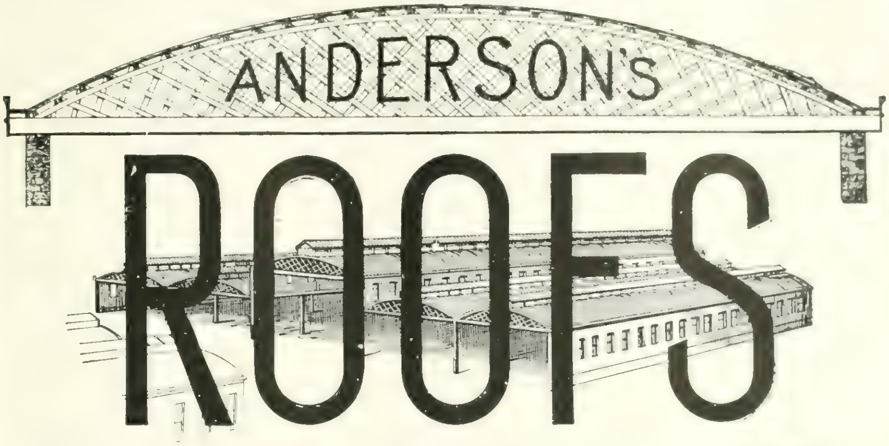

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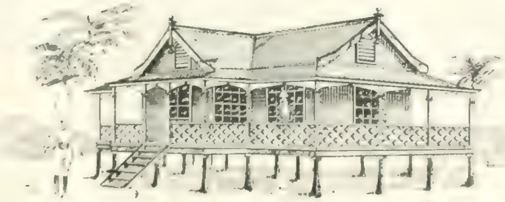

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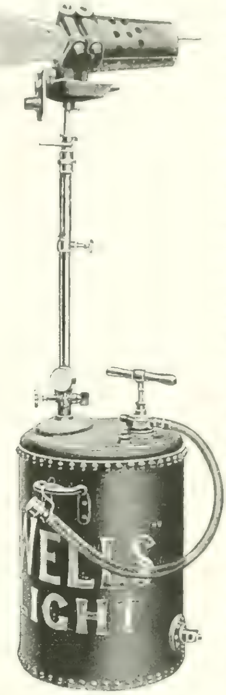

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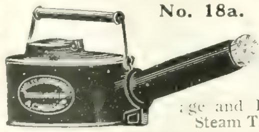

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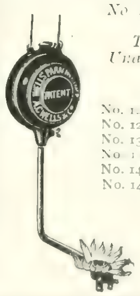

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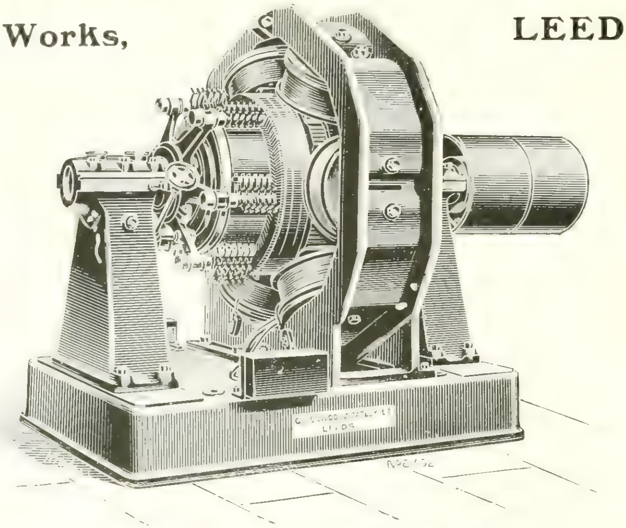

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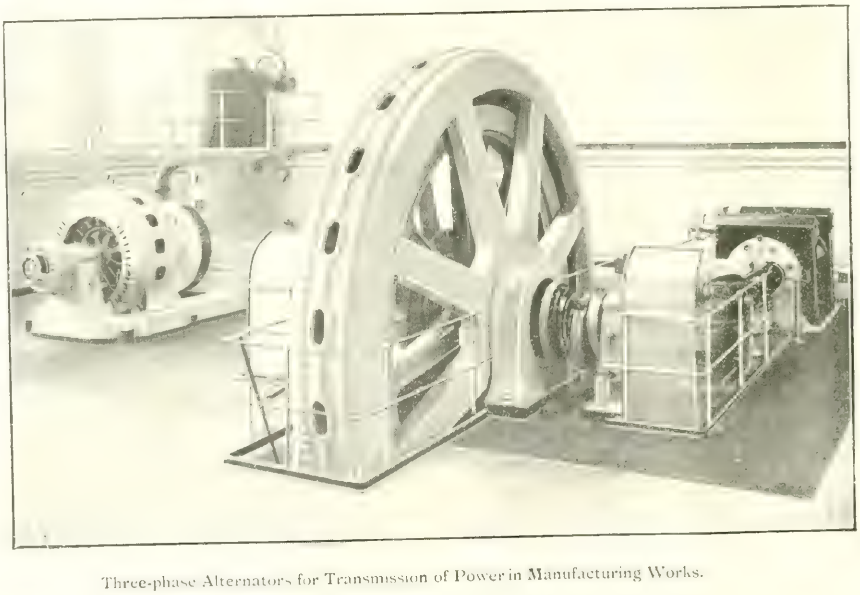

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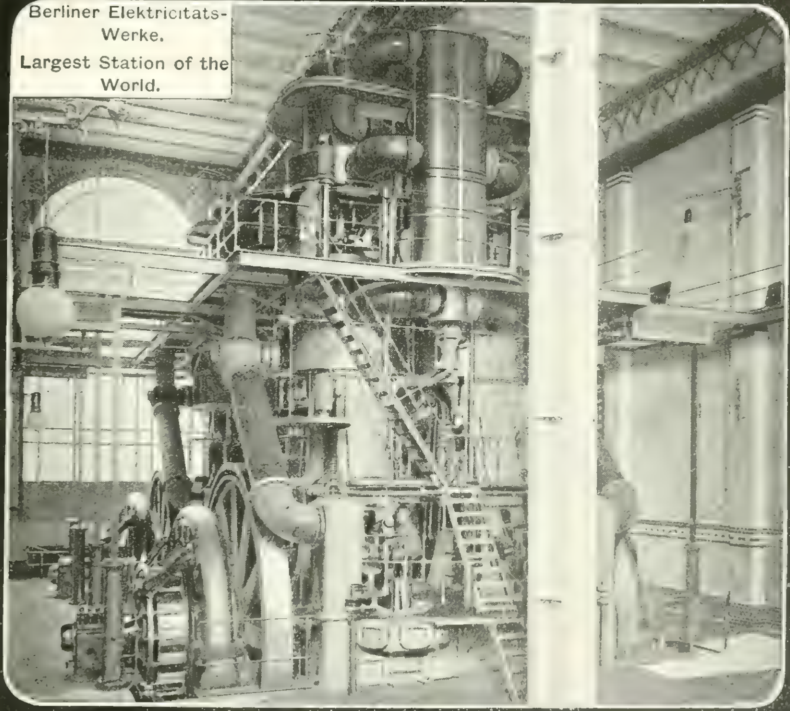

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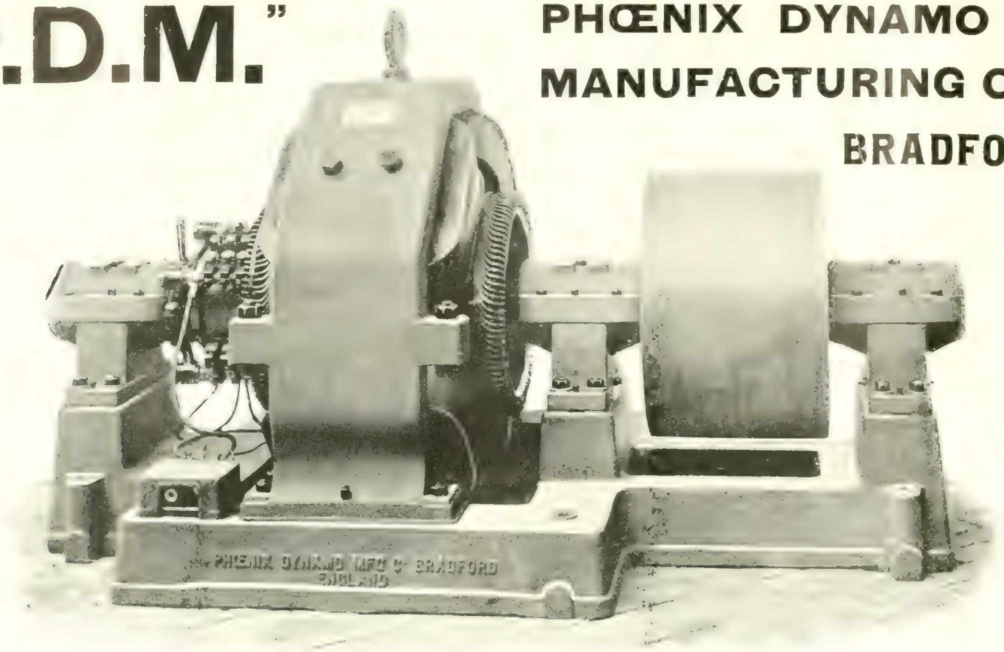

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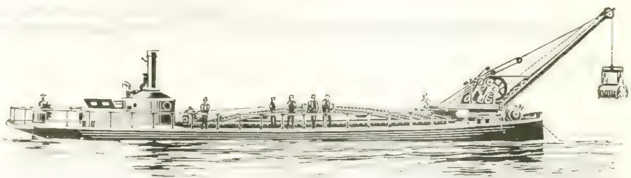

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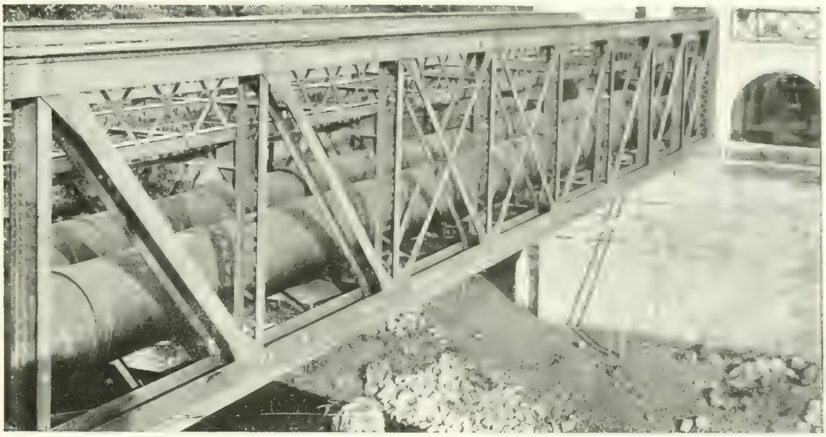

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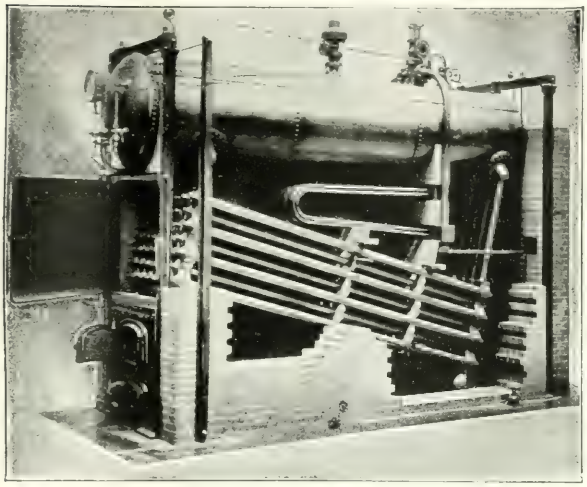

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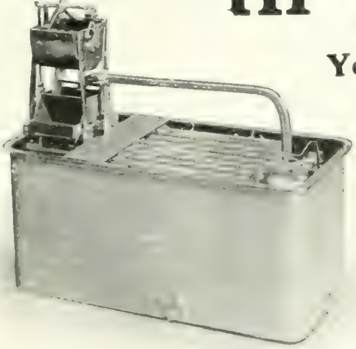

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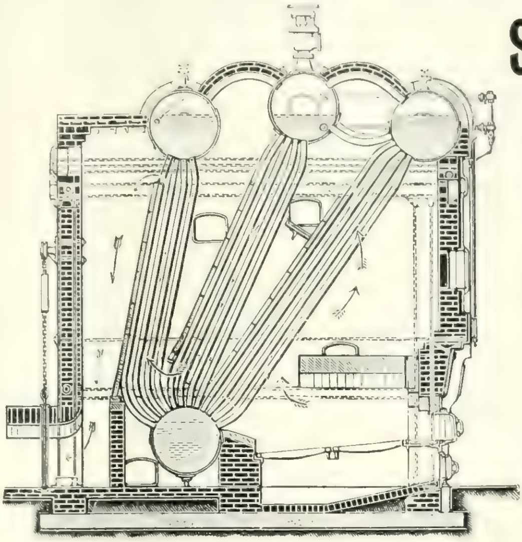

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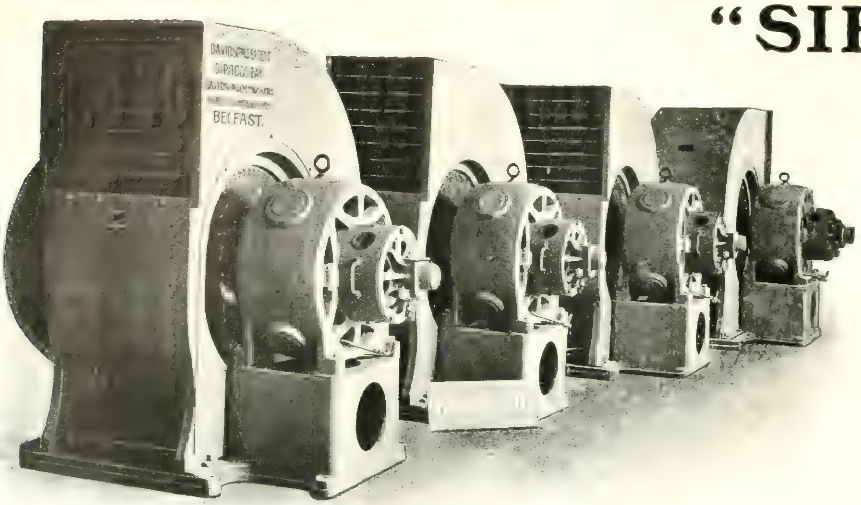

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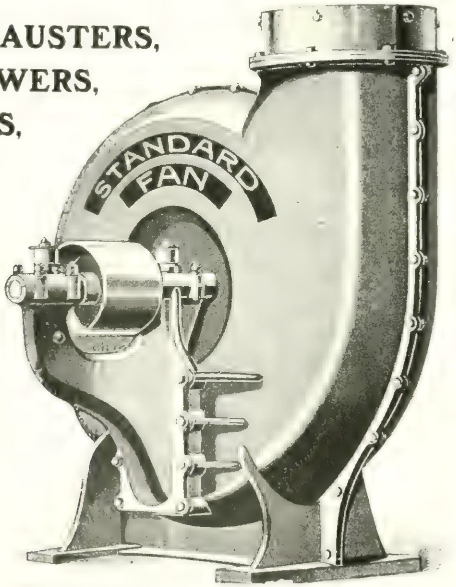

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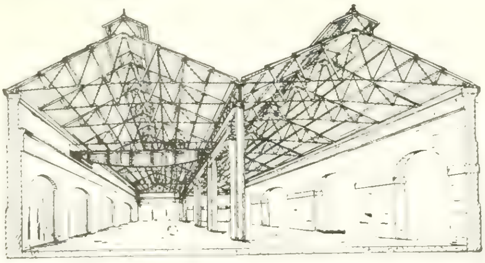

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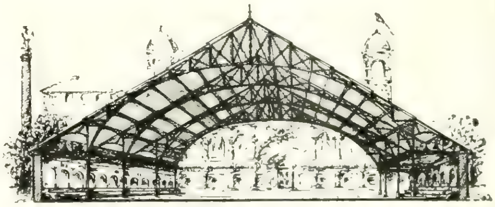

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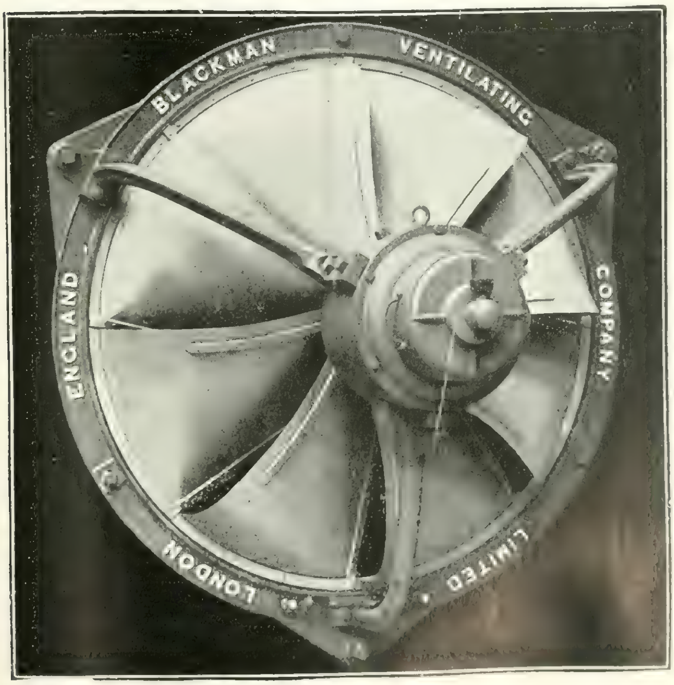

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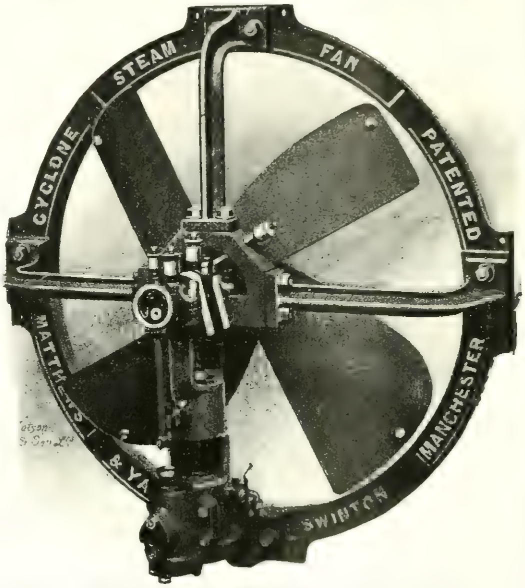

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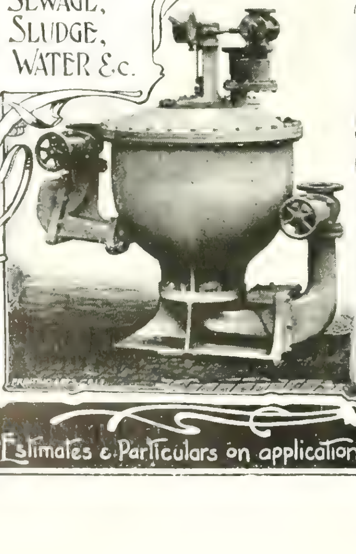

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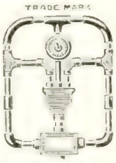

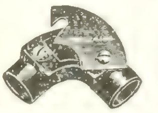

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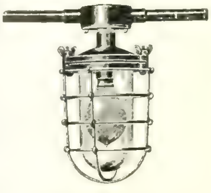

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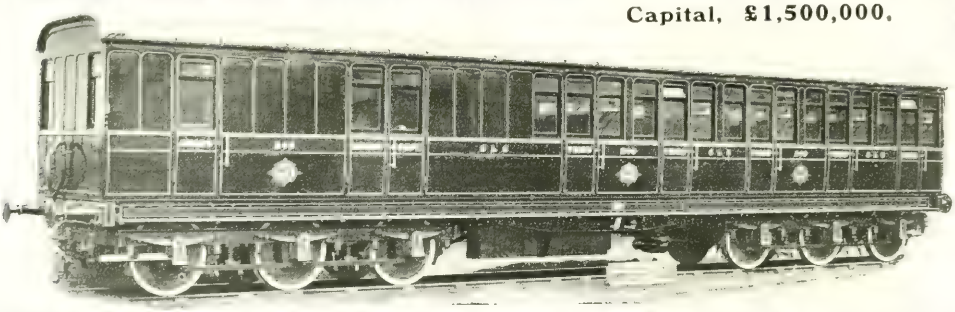

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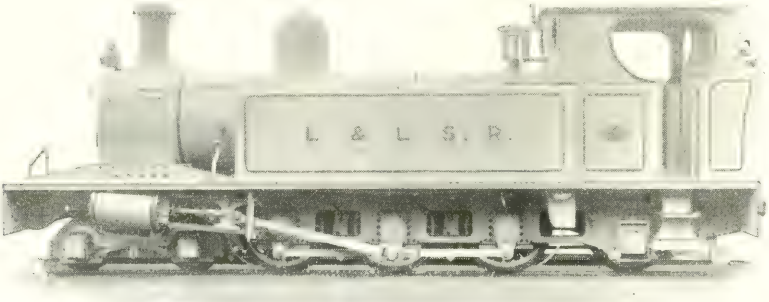

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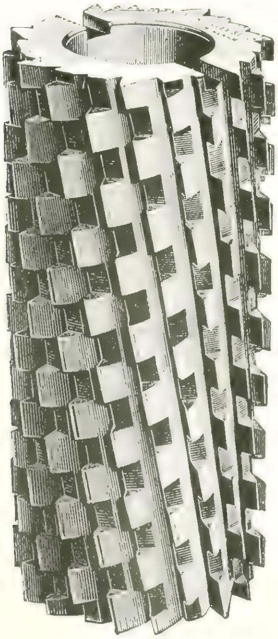

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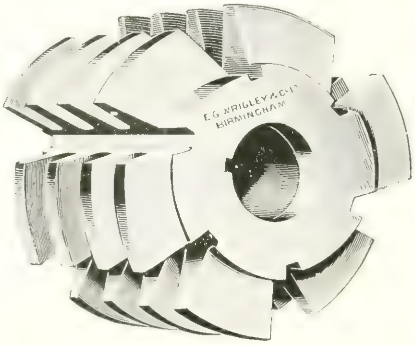
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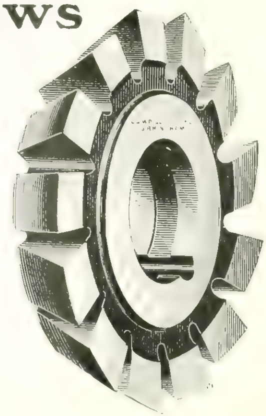

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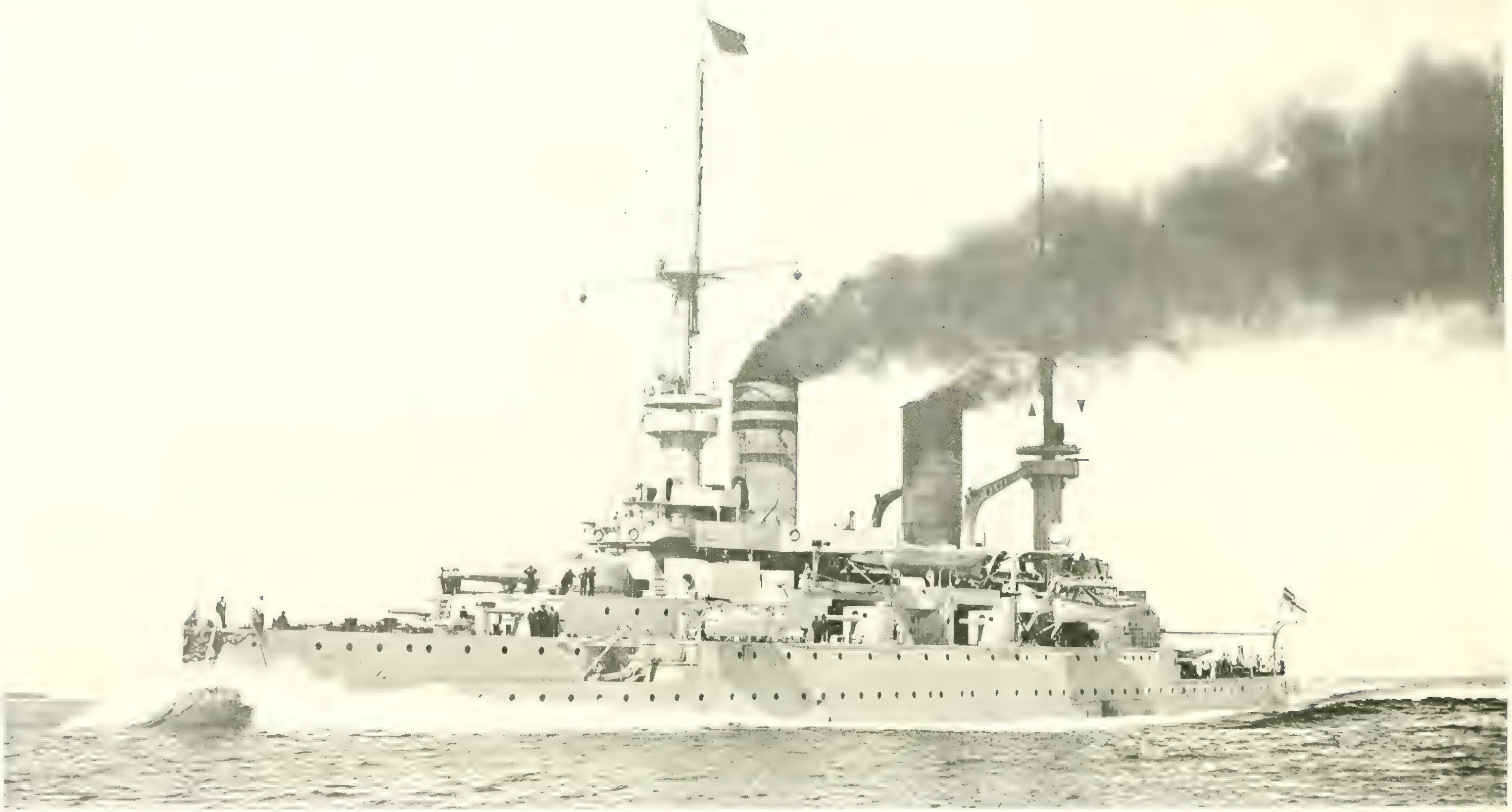
It is with considerable satisfaction, however, that we are able to inform our friends and subscribers that Page's Magazine is English in every sense of the word: English in thought, English in policy, backed by English capital, and dependent upon English brain. The paper is manufactured in Scotland, all the engraving and printing is done in London, and anyone who scrutinises the list of contributors will recognise some of the most distinguished names in British engineering practice.

Probably no magazine devoted to technical subjects has ever received the same welcome or achieved the same amount of success in a corresponding period, and we feel that this is due not only to the reasons referred to above, but also to the fact that the vast industries represented by Page's Magazine had need of a thoroughly independent and wholly English journal.

Without further enlarging upon the measure of success achieved, we would say that in our second volume we hope to cover a still larger field of usefulness, and to extend our circulation in every part of the world.

We cannot enter upon a second volume without a word of thanks to our readers and advertisers for their cordial support—a support which finds accentuation with each succeeding number of the Magazine.



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NEW GERMAN FIRST-CLASS BATTLESHIP "KAISER BARBAROSSA," 11,150 TONS; 13,000 I.H.P.; SPEED, 18 KNOTS.

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VOL. II. LONDON, JANUARY, 1903. No. 1

THE DISTRIBUTION OF GUNS IN BATTLESHIPS.

BY

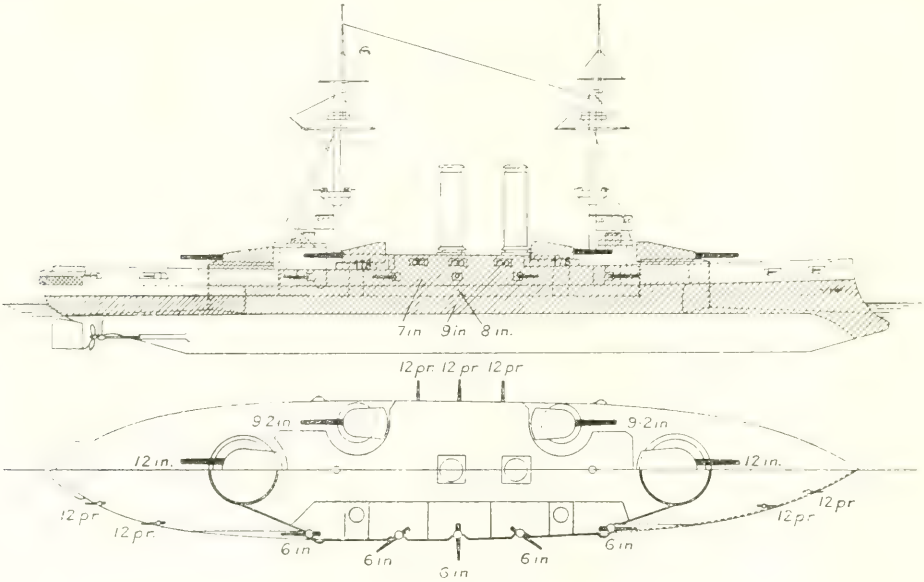
JOHN LEYLAND.

The author deals broadly with this important question, passing in review the latest developments in gun distribution at home and abroad. Incidentally he shows that naval science and mechanical ingenuity are leading up to a new development in the evolution of the battleship, and that, in the past, improvements in the system of gun-mounting have led to changes in naval tactics.—EDITOR.

RECENT changes in the character, mounting, and distribution of the armament of battleships introduced in the navies of the Powers, all tending to a great increase in offensive value, and adding at the same time enormously to the complexity of mechanical devices on board, seem to make a consideration of the question of armament of interest and importance in this place. The subject might be treated either from the tactical point of view, having regard to the manner in which guns may be brought to bear in various formations in action, or again purely in its technical aspect, with special reference to the systems of mounting guns, the devices for the turning of turrets and the hoisting of ammunition, all admirable examples of efficiency, and of means well directed to ends, and the hydraulic and electric appliances that are or may be employed. It should not be overlooked that tactical methods and mechanical improvements have acted and reacted on one another.

My purpose is to deal rather generally with the broad subject, and to show how the progress of naval science and of mechanical possibilities is leading to new developments in the character of battleships, which appear not yet to have reached finality. Signs are not wanting, indeed, that we may even now be on the threshold of a further step in the evolution of vessels of this class, and that the latest battleships, of which plans are published here, are far from being the last word of the ship designer.

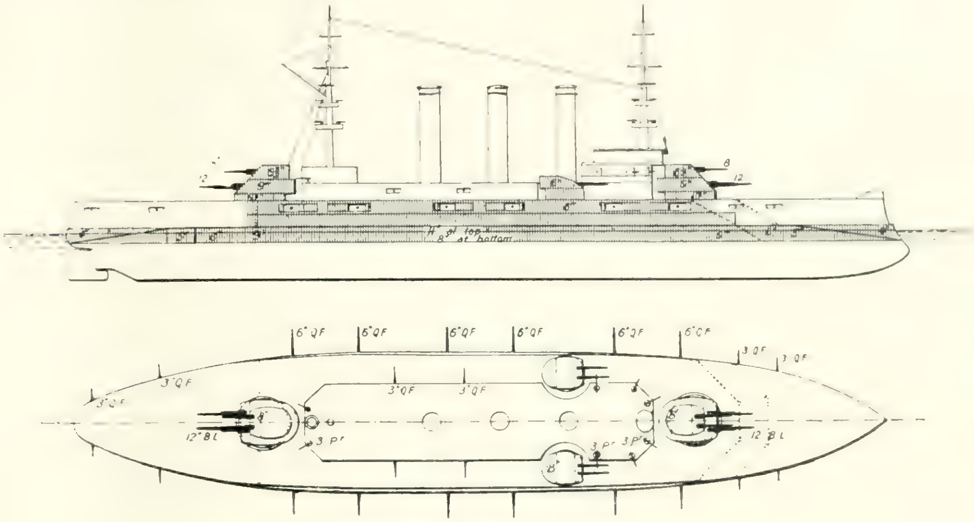
It is impossible in the space of a single article to cover more than a portion of a very great subject. The disposition of armament is closely related to that of armour, and the whole question is bound up with that of the stowage and supply of ammunition. It would be true to say that battleships are themselves gun-mountings, their function being to bring gun-power to bear upon an adversary. It is not, therefore, surprising that various ideas should have prevailed as to the distribution of armament. All through the great wars ships were built upon the historic broadside principle, and we passed within thirty years from the two and three-deck ships of 70 to 120 guns to the broadside frigate of from 20 to 40 guns. The old principle existed in the broadside ironclad, and it was not until after the American Civil War that the turret system began to work the revolution which has given us the battleship of to-day, wherein the turret and broadside systems are combined. Vessels built to use the ram, or to engage in line abreast bows on to the enemy, would necessarily differ in their armament from vessels constructed to fight in line-ahead, using their broadside fire mainly; but in modern times a combination of the two principles has been everywhere accepted, so that ships may engage with more or less advantage in any formation, but chiefly in line-ahead, or in bow and quarter line, depending chiefly on bow, beam and quarter fire. These are matters into which I shall not enter further. They are of professional interest to naval men, though they very materially affect the mechanical arrangements on board ships of war.



"KING EDWARD VII." (BRITISH).

BRITISH v. FOREIGN SHIPS.

Five years ago it was possible to say that the type of battleship which was introduced by Sir William White in 1889 had been copied almost everywhere abroad. The French had abandoned the lozenge-like arrangement of heavy guns, as used in the *Hoche Magenta*, *Jauréguiberry* and *Carnot* classes, in which four heavy guns are mounted in as many turrets, one forward, one abaft, and one on either beam; the Russians no longer placed six guns in three barbette turrets at the corners of a trilateral citadel, as in the *Sinope* class; and the Germans had forsaken the arrangement of three turrets in the keel line of the ships, as in the *Brandenburg* and her sisters. In every navy the armament consisted of four heavy armour-piercing guns, in two turrets or barbettes, with a powerful secondary quick-firing battery, usually in casemates, between. Now we find a further development being made in all navies upon parallel lines in the decline of the casemate, and the adoption of the turret for some or all of the secondary guns. We must not be ashamed to learn from other Powers important elements in naval efficiency. France long stood forward as the champion of turrets, while we held to the casemate, which we have now abandoned for the box-battery or citadel in the *King Edward VII.* class, adding four turrets for four 9·2-in. guns on the deck above. It was no new thing for the French to give us a lead in naval matters. Charnock observes that when, in the old wars, our adversaries captured an English ship, they either put her on a lower rating or threw her aside, and that the ships which they lost at sea were almost invariably British built, while the ships which we captured from them generally outsailed those built in our own establishments. Captured vessels were largely the models from which we built, and Rear-Admiral Eardley-Wilmot points out that as late as 1850, out of 150 ships in the Navy List, upwards of 50 were from foreign models, and even Spanish types were thought worthy of being copied. As we took the turret from the Americans and the French, so did we follow the



"GEORGIA" (UNITED STATES).

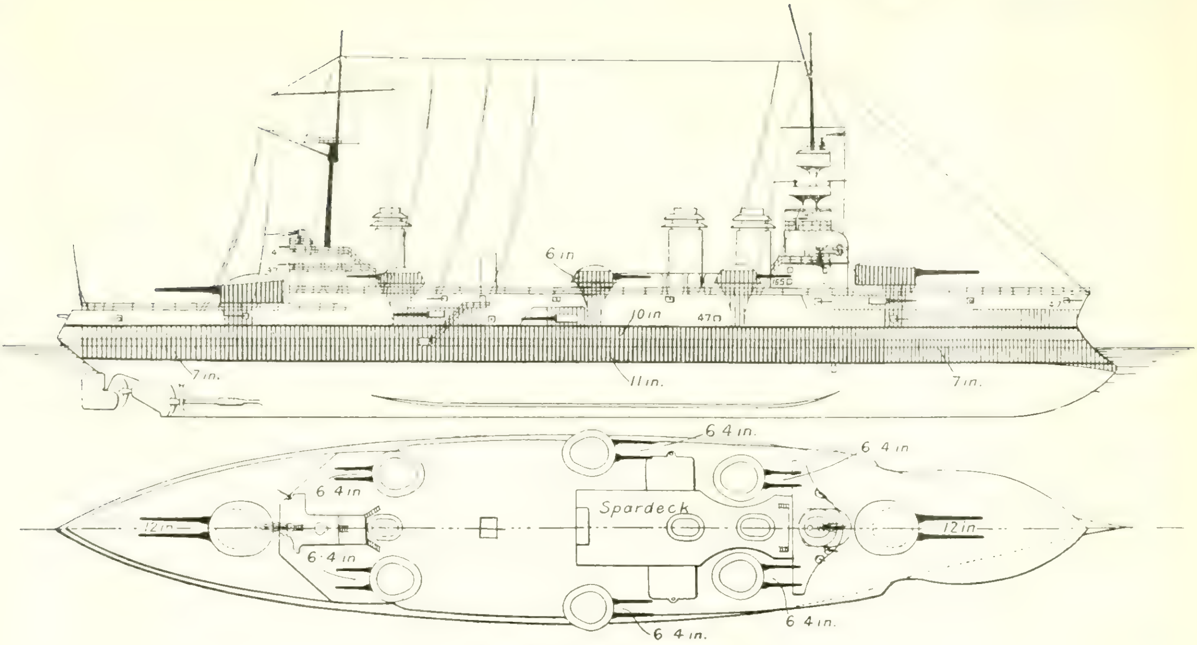
French in the introduction of armour. It would, of course, be incorrect to suggest that foreigners have always been ahead of us in such matters, but the fact that we have learned much from them, should make it interesting to study the types of ships which they have introduced. A battleship is a compromise, and an excessive weight in armament will necessarily find its compensation in some weakness elsewhere—in the matter of protection, engine power, or coal capacity. Nevertheless, there has been much reason to think, perhaps more especially in relation to cruisers, that our ships have been under-gunned in comparison with those built by other Powers. The same is true in some measure of our battleships. The following table shows the estimated total energy of fire per minute discharged by certain modern battleships in foot-tons per ton of displacement, as given in the *Naval Annual* :—

British ...	"Renown" ...	20·4
"	"Majestic" ..	26·4
"	"Formidable" ...	34·34
"	"Duncan" ...	34·08
French	"Charlemagne"	38·1
"	"Iéna"	35·73
German	"Kaiser Friedrich III."	52·04
Italian ...	"Saint Bon" ...	23·1
"	"Benedetto Brin" ...	47·83
Russian	"Petropavlovsk"	45·10

These figures illustrate the tendency on the part of foreigners to place heavier armaments in their ships than are commonly found in our own, but they cannot be regarded as absolutely representative of relative fighting power. Calculations might be made in other ways, but, perhaps, for the moment, the indication is sufficient. The table does not show the predominance which is claimed by the United States Navy in the armament of its latest vessels, wherein it is endeavouring to justify in practice the old boast that American ships have always been better armed than any others in the world. The very important question of the protection of guns must not be forgotten, and an examination would show that we are far from the days when the battery guns were left without protection, and when heavy gun positions were left with their bases exposed to the enemy's fire. It has certainly been made a reproach to the French ships of the *Charlemagne* and *Iéna* classes that they have insufficiently protected positions for their 6·4-in. guns, these being placed in what have been described as "aerial casemates"—a description which does them injustice, but suggests their faults—and it would not be difficult to indicate similar cases. Moreover, in view of the penetrating power of modern guns, it seems likely that the armour of the main barbettes will have to be the [illegible]

THE DEVELOPMENT OF ARMAMENT IN BATTLESHIPS.

Before describing the disposition of guns in the most modern types of battleships, I shall now

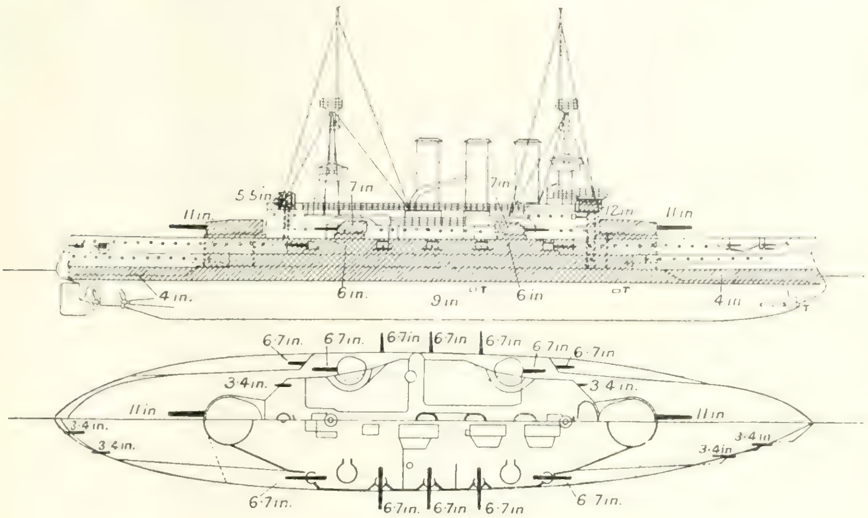


"REPUBLIQUE" (FRENCH).

sketch briefly the evolution of that disposition since the introduction of the turret. Although Ericsson has received the credit of originating the revolving turret in the *Monitor*, the work of Captain Cowper Coles, a little earlier, must not be forgotten. Seeing the disadvantage of laboriously changing the direction of a gun by tackles and handspikes, as in the old times, he proposed what he described as "the horizontal motion or training effected by turning the shield itself with the gun crew, and the platform on which they stand, the whole apparatus thus becoming, as it were, the gun carriage, and being placed on a common turntable, revolved to the greatest nicety by means of a winch." The turret revolved on rollers on its lowest circumference, being a much better arrangement than the spindle system of the *Monitor.*

Here, obviously, was the germ of the modern revolving turret and barbette, admirably controlled in the movement of its mighty mass, its coupled guns, its deep level turntable and hoisting apparatus, weighing, it may be 500 tons, turned on its ball-bearings with the utmost ease, and arrested, in the most recent ships, at any 200th interval in an inch without jolt or jar. The old *Monitor* confirmed the value of the turret, though the loss of the *Captain*, in 1870, off Cape Finisterre, with Captain Coles, the principal advocate of masted turret ships, on board, led the Admiralty for a time to abandon the type.

The advantage of the turret was, and still is, the large arc of training it gave to the main guns on either side of the ship, the whole armament being brought into play instead of one-half, as in the case of a broadside ship. Thus did mechanical ability influence the tactics of the sea. In modern ships the principal guns will move through an arc of as much as 270 deg., and the secondary turret guns at the sides through 150 deg. or more. The *Devastation* was our first mastless seagoing turret-ship, and the old *Dreadnought* was the next improvement, and the type from which it may be said our modern ships have sprung. In the *Edinburgh*, based on the general lines of the older *Inflexible*, the idea was to have two turrets, each with two 12-in. breech-loaders placed in eschelon amidships, with the purpose of enabling the four heavy guns to fire on either broadside or right ahead or astern. The same principle is found in the American *Texas*. The advantage was more apparent than real. The *Conqueror* and *Hero*, launched in 1881 and 1885, are of the single turret type, with two 43-ton guns, their lineal predecessors being the *Hotspur* and *Rupert*. There were disadvantages in concentrating the main gun-power in a single turret, and the origin of the idea may be found in the vogue which was given to the ram, it being intended that the ship should bear down upon her enemy, and, just previous to the disastrous blow, discharge an overwhelming fire. In the *Sans Pareil*, and her ill-fated sister the *Victoria*, the want of stern fire was partially compensated by placing a 29-ton gun aft, behind a heavy barbette shield, but this gun, to use a French phrase, is " aerial," while the whole broadside of 6-in. guns is quite unprotected, and the real defence is for the huge 110-ton guns mounted side by side in the forward turret. The "Admiral" class represents an improvement. They differ among themselves, but all have a pear-shaped barbette at each end for one or two heavy guns, and a broadside battery of 6-in. guns between, though these are still unprotected, while the low free-board might be a considerable impediment to the fighting of the big guns in a heavy seaway. The *Nile* and *Trafalgar* marked a very considerable improvement, and are still powerful fighting ships, because they have a central citadel containing the two turrets, and a box battery, as a defence for their 6-in. guns.



GERMAN BATTLESHIP, "H" CLASS.

It is not necessary to describe the ships of the *Royal Sovereign* class, in which there were further improvements, the demand for protection having grown, and the ships carry two 13·5-in. guns in each of their barbettes, and ten 6-in. quick firers. They had not, indeed, gun protection such as these times require, and are now receiving casemates for the guns on the upper deck, which hitherto have only had shields. The *Majestic* class have the new 12-in. wire guns in their barbettes, and their twelve 6-in. guns all in casemates, six on each broadside. The *Formidable* class marks a still further advance, mainly in the matter of protection and coal capacity, and the general arrangement of the armament remains the same.

The same is true of the *Canopus* and *Duncan* classes. In all these ships there is ample protection for the bases of the big gun turrets, as well as of the casemates, and the armouring constitutes a central citadel, with a barbette turret and transverse bulkhead at either end, and thinner armouring extended to the bows.

RAPIDITY OF FIRE AND LOADING ARRANGEMENTS.

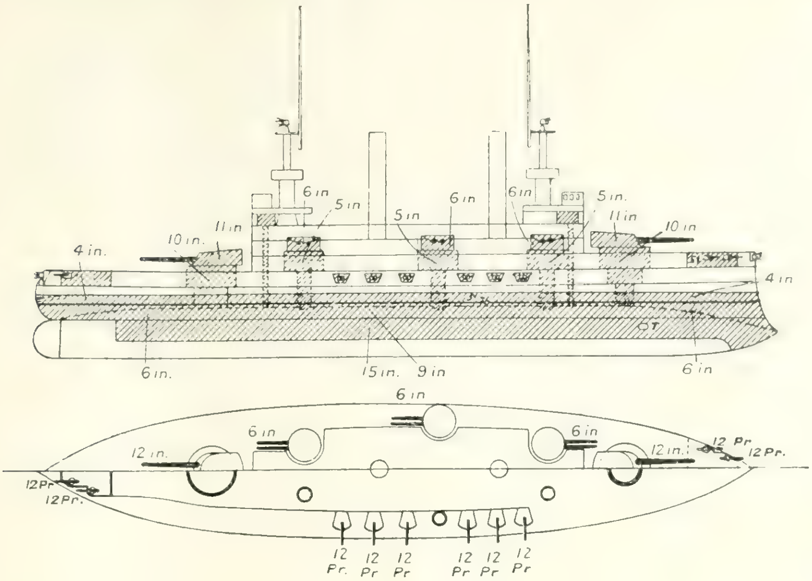
The great advance in the system of gun mounting has done more than anything else to improve the fighting value of ships. In the case of the heavy guns a system of all-round loading is of primary importance for rapidity of fire, but such was not provided in the ships of the *Majestic* class, owing to delays that would have occurred. The *Canopus* mounting, designed at Openshaw, was, therefore, the first for all-round loading in the British Navy. A roomy working table is below the turntable, into which ammunition is brought by central hoists, and hydraulic overhead travelling cranes are fitted to transfer the shot to the gun hoists. In the *Albion*, the projectiles are brought to the gun hoists by surrounding the bottom of the ammunition trunk with a revolving platform running on rails on the ship's bottom; in the *Formidable*, by supplying two shot carriages running on rails carried at the bottom of the trunk of the hoist; in the Japanese *Shikishima*, by using a double overhead rail, half moving with the hoist and half fixed to the ship; and in the *Mikasa*, the interior and bottom portions of the hoist revolve within the fixed chamber. Devices have also been prepared for bringing up projectiles direct from the bottom of the ship to the gun. All such arrangements involve complexity, but simplicity combined with efficiency is sought. Hydraulic and electric systems are employed, and in the new American ships the very large chamber below the gun gives every facility for ammunition supply with alternative methods of hoisting. Rapidly-moving endless chain gear is also an American feature for supplying ammunition for quick-firing guns. The effect of such arrangements has been greatly to increase the rapidity of fire with heavy guns. Thus, in the "Admiral" class, one round in three minutes is barely possible; in the *Royal Sovereign*, the period is slightly over two minutes; in the *Majestic*, it is a little more than one minute. The *Ocean*, which has made splendid target practice in China, has fired her 12-in. guns at the rate of one round per minute, with all-round gear, the shell being brought from below, and the *Mars* and other ships appear to have done as well. The disadvantage alleged against turrets for secondary guns is that they reduce the rate of fire as compared with the working of casemate guns, but this is uncertain. Now that such turrets are being fitted in our new ships the relative advantages and disadvantages should be no longer in doubt.

MODERN TYPES.

Having now described the evolution of armament and its distribution, and having suggested some of the difficulties of mounting guns advantageously, I shall describe new features in the most modern types. The following table is interesting:—

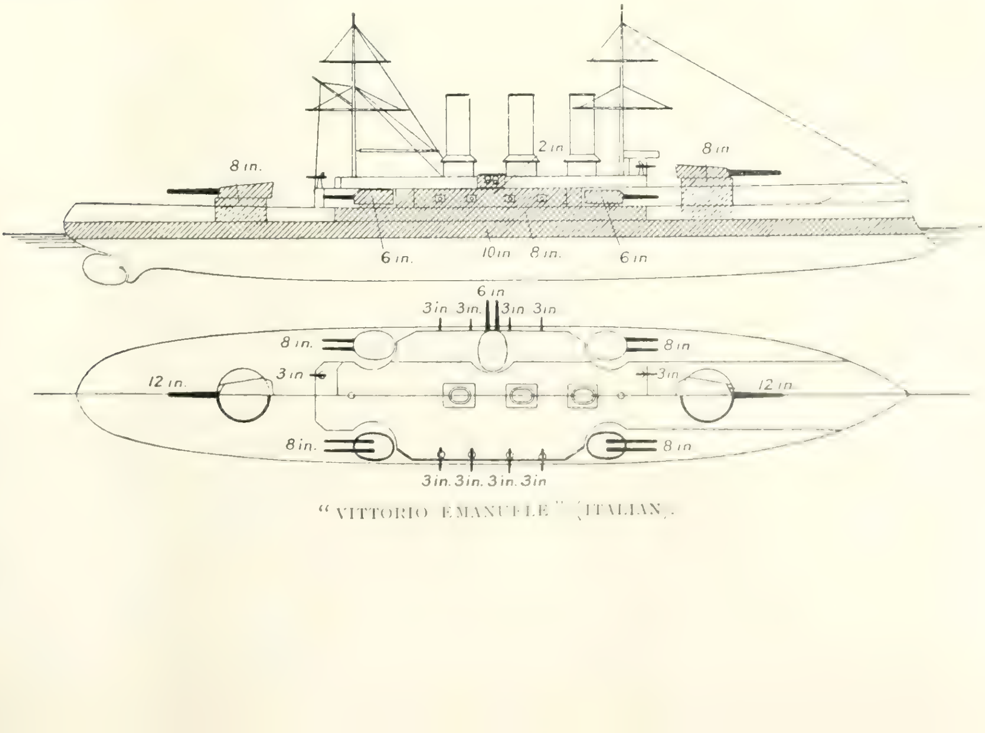
		Displacement.	Principal Armament.				Weight of Discharge, lbs.
		Tons.	Turret Guns.		Casemate or Battery Guns.		
British.	"King Edward VII."	16,350	4 12-in.	4 9·2-in.	10 6-in.	—	5,020
U.S.	"Georgia"	14,948	4 12-in.	8 8-in.	12 6-in.		6,600
"	"Connecticut"	16,000	4 12-in.	8 8-in.	12 7-in.	—	7,380
French.	"République"	14,865	4 12-in.	12 6·4-in.	6 6·4-in.	—	5,470
German.	"H" Class	13,200	4 11-in.	4 6·7-in.	10 6·7-in.	—	4,400
Russian.	"Borodino"	13,600	4 12-in.	12 6-in.	—	—	4,600
Italian.	"Vittorio Emanuele"	12,624	2 12-in.	12 8-in.		—	4,700
Austrian	"Ersatz Laudon"	10,600	4 9·4-in.		8 7·5-in.	6 6-in.	4,330

In the table two points will be evident. The first is, as I have already suggested, that foreign ships, ton for ton, are generally more heavily armed than our own. A comparison between the new American ships and the *King Edward VII.* class will emphasise the point, and in reference to these particular ships it may be noted that the American vessels are credited with half a knot better speed, but with 50 tons smaller coal capacity, though it would not appear that the *Connecticut* will be inferior in the latter matter. The other point to which I would draw attention is the great extent to which the turret is now employed for the secondary guns. Its rise has corresponded with the decline of the casemate. Box batteries were adopted for the 4·7-in. guns in the *Nile* and *Trafalgar*, but the casemate came in with the Naval Defence Act, and was introduced in all our armoured ships. No nation took up this system of gun protection so thoroughly as ourselves, though it has been used by the French and the Germans in combination with box batteries and turrets. Turrets, however, have usually been preferred. It is now, indeed, generally recognised that armour admitting shot or shell through the ship's side between the casemates is likely to give no sufficient protection



"BORODINO" (RUSSIAN).

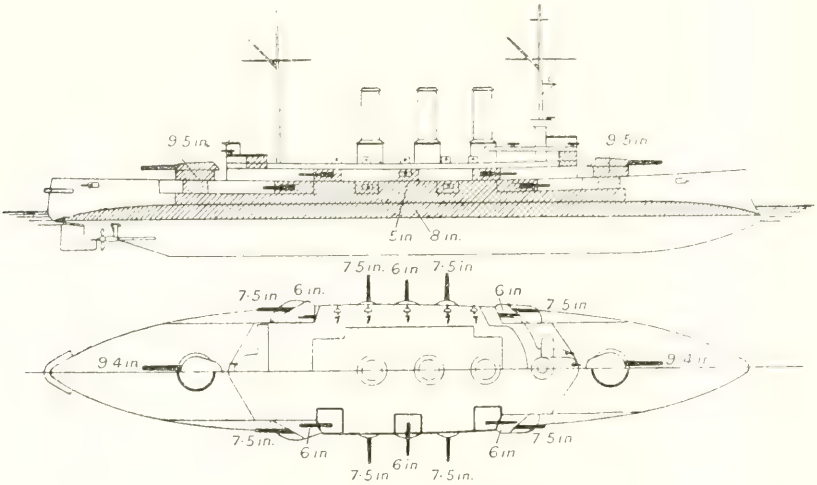
against damage from projectiles entering the rear of the casemates on the opposite side. Upper deck casemates possess many disadvantages, and admit of guns being trained to not more than about 25 deg. abaft the beam, and not quite direct ahead, whereas a turret gives a large raining arc, and makes the gun good for ahead or astern fire, and also for fire on the broadside. Turrets, however, cannot be used on the main deck, where, for greater protection of the broadside guns, we find the enclosed citadel or box battery being introduced. The *Mikasa*, built by Messrs. Vickers, Maxim for the Japanese Government, has an interesting feature of design in connection with the disposition of armour on the side. Instead of applying the scattered casemate system, there is a new arrangement in which the casemates are concentrated within the central battery, so that there is no unprotected space between. Complete isolation is given for each of the 6-in. guns, along with a continuous armour-plated side for the full depth of the ship throughout a great part of her length. Thus, should the ends of the ship be riddled and admit water, the remaining freeboard being armoured would ensure extra buoyancy. The same system has been adopted in the ships of the *King Edward VII.* class, and is acknowledged to be a very great advantage, but the special feature of our latest type of battleship is the placing of four 9·2-in. guns, two firing ahead and two astern, in as many barbette turrets on the



"VITTORIO EMANUELE" (ITALIAN).

upper deck at the corners of the citadel, while the ten 6-in. guns are in the central battery, as has been described, separated by armoured screens.

Let us now see how the same system is to be applied in the new American ships. Here it deserves to be noted that in the *Kearsarge* and *Kentucky* a system was adopted of mounting a turret containing two 8-in. guns on the top of the main turret. This disposition of armament led to a great controversy in the United States, some holding that an immense advantage was secured in the training together of two 12-in. and two 8-in. guns upon the same object, while others contended that this advantage was much more than compensated by the great danger of the whole four guns being put out of action together, by damage to the huge double turret. In the *Maine* class, therefore, the superposed system was abandoned, but it was taken up again in the *Georgia* class, in which the superposed turrets have a continuous inclined front, a considerably reduced port opening, and the turning motors removed from the rotating structure to the protected deck within the barbette. In the latest class, represented by the *Connecticut* and *Lousiania*, which are just being put in hand, the turrets are not to be superposed, but the advantage of numbers and the turret system have been retained, while in the battery the twelve 6-in. guns are replaced by twelve of 7-in. calibre. The main armament will consist of four 12-in. guns in electrically controlled turrets, while eight 8-in. guns will be coupled in four like turrets placed at each corner of the superstructure. The 7-in. guns will be on pedestal mounts, protected by 7-in. armour, with nickel steel splinter bulkheads. All the turret guns have a very wide angle of fire. The total armament will weigh 945 tons, and will include twenty 14-pounders, twelve 3-pounders, and about eighteen smaller guns, constituting the largest armament ever placed in a battleship.

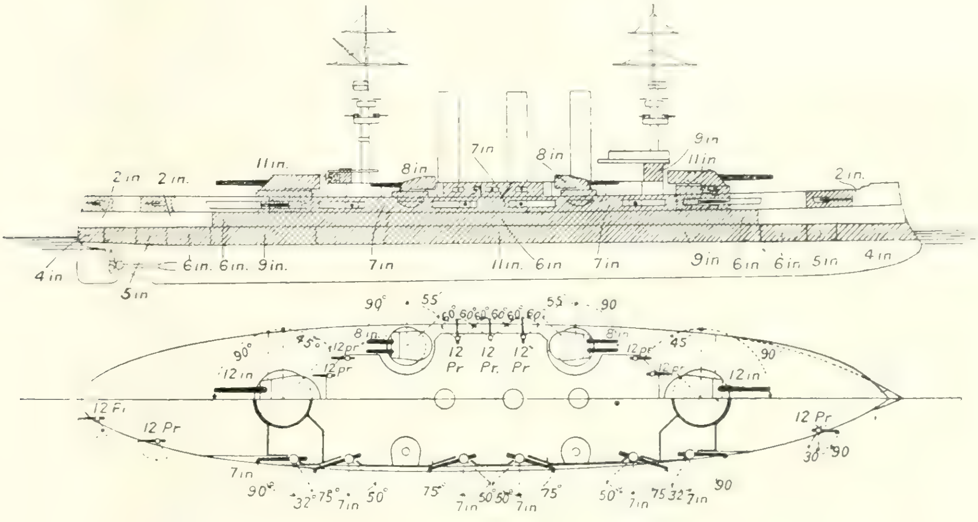


"ERSATZ LAUDON" (AUSTRIAN).

The *République* is the largest vessel which the French have yet afloat, and the artillery predominance, having regard to displacement, is very marked, except against the later American classes, as may be seen by the table. The new French class is very remarkable, because, in addition to the four 12-in. guns coupled in the two main turrets in the customary way, well protected at the base, twelve of the eighteen 6·4-in. guns are in pairs in six turrets on the upper deck, four of the turrets being at the corners of the superstructure, and one on each broadside. All the communications of the turrets are protected, but it may be argued that if the ships were riddled with shot or shell below them, much of their support would be carried away, and their narrow bases might prove insufficient to prevent them from falling over.

The effect of the arrangement is, however, very good, for, of the 12-in. and 6·4-in. turret guns, ten can be brought to bear almost right ahead or right astern, and as many on the broadside. The ship is thus well adapted for all-round fighting in almost any line of bearing to an enemy. The design is by M. Bertin, the most eminent of French naval constructors.

The latest German ships of the "H" class are a great improvement upon their predecessors, because, instead of 9·4-in. guns in their main barbette turrets, they have 11-in. guns, 40 calibres long, which in energy and rapidity of fire, are said to be almost equal to the 12-in. guns of other Powers. The secondary guns are also more powerful than in those of the immediately preceding *Wittelsbach* class, and four of them are in revolving turrets on the upper deck, like the 8-in. guns of the American ships, while the others are in battery in the citadel. The Germans are well pleased with their new design, and contend that they have an advantage in adopting a single calibre for the secondary guns, while they claim a greater rate of fire for all their pieces than can be attained by the guns of the *King Edward VII.* class. They thus regard themselves as having compensation for a somewhat smaller weight of discharge.



"CONNECTICUT" (UNITED STATES).

A comparison of the diagrams of the new French class with those of the *Borodino* and her sisters now being added to the Russian Navy, will show that many points of similarity exist between them. Here again are four 12-in. guns in well-protected barbette turrets, and twelve 6-in. guns in pairs in six turrets. All the bases of these gun positions are well armoured, but, as in the French class, each turret, with its long support, has a tower-like character, which seems to present a certain danger under heavy fire. The *Borodino* and her sisters are inferior to the other ships which have been described, but, except in comparison with the German vessels, they have smaller displacement. They are, however, provided with very large coal capacity, and thus have an extended range of action, which is doubtless thought to compensate for some deficiency in armament.

As to the Italian and Austrian ships, of which diagrams are given, not much need be said. The *Vittorio Emanuele* is, nevertheless, a very interesting vessel. In each of her two main turrets she carries only a single 12-in. gun, but she has a great advantage in having twelve 8-in. guns in pairs in turrets, as in the French and Russian ships. The Italian turrets, however, seem to possess very much better protection below, so that the ship could stand a much heavier battering than the others alluded to. There is another ship of the type, the *Regina Elena*, and others are to be built. It may be observed that they approximate a good deal to the armoured cruiser class, having a speed of 22 knots, and are not in any way deficient in coal capacity, since they will carry 50 tons more even than the *King Edward VII.* class. Altogether they are very remarkable vessels. The new Austrian type, represented by the ships of 10.600 tons, which is being built to replace the *Laudon*, cannot well be compared with the other vessels. The four barbette guns are of 9·4-in. calibre and the large secondary armament of eight 7·5-in. and six 6-in. guns is in the citadel, and in single casemates superposed thereupon. It may be noted that these vessels are to steam at 19 knots.

This brief survey of the armament of battleships has shown how the revolving turret introduced after the American Civil War effected a profound change in naval construction ; what form it took, converted into a barbette, in combination with a broadside armament ; how that broadside armament gained protection, and how the protection given came to be thought inadequate ; then how the citadel or box battery was revived, and how a larger number of guns have lately been mounted in turrets upon the upper deck. The result has been to increase very largely the angle of fire open to guns, and thus, in the development of naval tactics, to enable vessels to go into action with advantage upon almost any line of bearing. The constant tendency has been towards greater protection for gun positions. The barbette guns lying exposed are now replaced by pieces under armoured hoods. so that the distinction between the turret and the barbette is breaking down. No ships are now built in which the bases of turrets or casemates are left without protection. The whole subject of protection is, however, beyond my scope. In these days of high explosive charges, the problem has been to a certain extent changed, and a secondary armament, capable of a rapid discharge of shell, has assumed a more important place in naval construction. Hence the greater care given to the protection of such guns. The mechanical progress in all that relates to gun mountings, the provision of armoured ammunition hoists, the ingenuity with which hydraulic and electric appliances have been introduced, are all a great demonstration of what modern times have accomplished. Constructors of warships have achieved a triumph, and, as I said at the beginning, there is some evidence that the end of their work is not yet, and that new avenues of progress are opening out to them.

THE BUILDING OF AN AMERICAN LOCOMOTIVE.

BY

FRANK H. FAYANT.

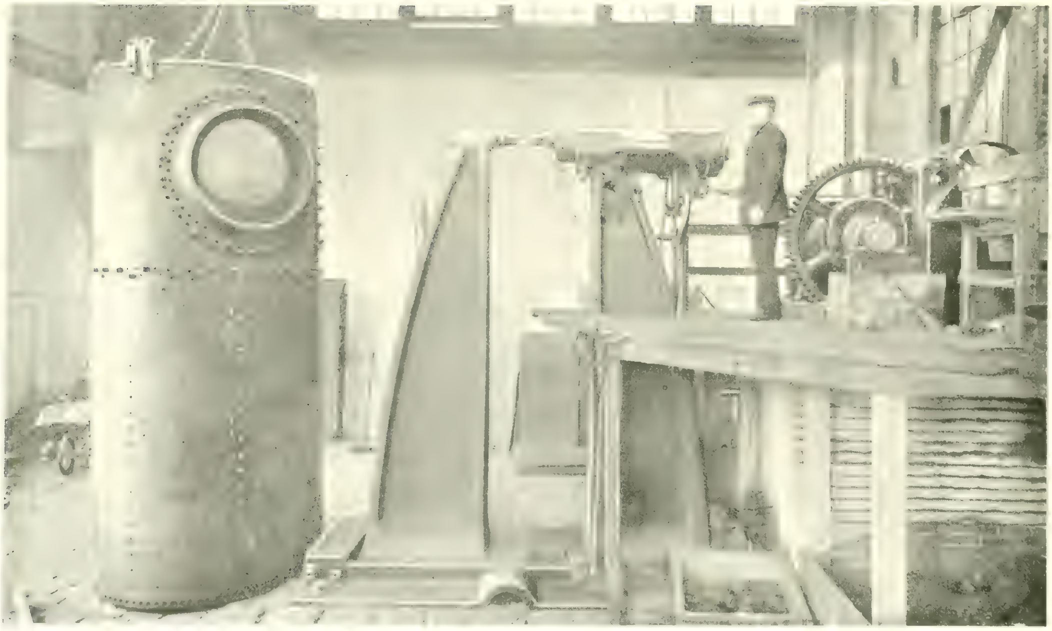
An American account of standard locomotive construction in the United States, based upon practice in the Baldwin shops. The article follows the work through the foundry and forge, the various machine shops, and erecting shops.—EDITOR.

WE find that the fundamental idea in American locomotive construction is power. This principle of design is the outgrowth of the development of trans-continental lines, hauling through-freights long distances in a sparsely settled country. To bring the products of the Western farms and ranches, mines and forests, two thousand miles across the country to the Atlantic seaboard it has been found that economy of transportation lies in heavy train-loads. Earnings increase with ton-miles; but expenses increase with train-miles. Traffic managers, therefore, seek to increase ton-miles more rapidly than train-miles. This is done by increasing train-loads. The traffic statistics of the Pennsylvania Railway Company, for example, show that last year, while the ton-miles were increased by 221,000,000, the train-miles were actually decreased by 575,000. The following table analyses the freight earnings of the Pennsylvania Company for the past three years :—

	1899.	1900.	1901.
Tons per train...	470	480	490
	dols.	dols.	dols.
Ton-mile revenue	.00473	.00530	.00580
Train-mile revenue	2.22	2.61	2.93
Ton-mile profit...	.129	.177	.205
Train-mile profit	.606	.86	1.03

FREIGHTS AND LOW MILEAGE.

Or, to look at the broad figures of operation, the Pennsylvania's lines last year carried 28,000,000 more tons of freight and 22,000,000 more passengers; its gross earnings showed an increase of 23,400,000 dols., and its net earnings an increase of 10,200,000 dols. But the total mileage of all its trains, despite this enormous increase in traffic and earnings, was no greater than the year before. The New York Central is hauling wheat trains of a hundred cars, stretching out two-thirds of a mile, and weighing 4,000 tons. On the mountain divisions of the railways of the American West enormous loads are being hauled. In the passenger traffic the increase in train-loads, without loss of speed, is equally remarkable. One of the new "Atlantic" engines on the New York Central has hauled on



HYDRAULIC RIVETTING MACHINE. MESSRS. BURNHAM, WILLIAMS AND CO.

800-ton passenger train at the speed of sixty-three miles an hour; another has a record of sixty miles an hour with a 900-ton train; while another engine, drawing a 600-ton train, has covered 111 miles in 109 minutes.

MASSIVE DESIGN OF AMERICAN LOCOMOTIVES.

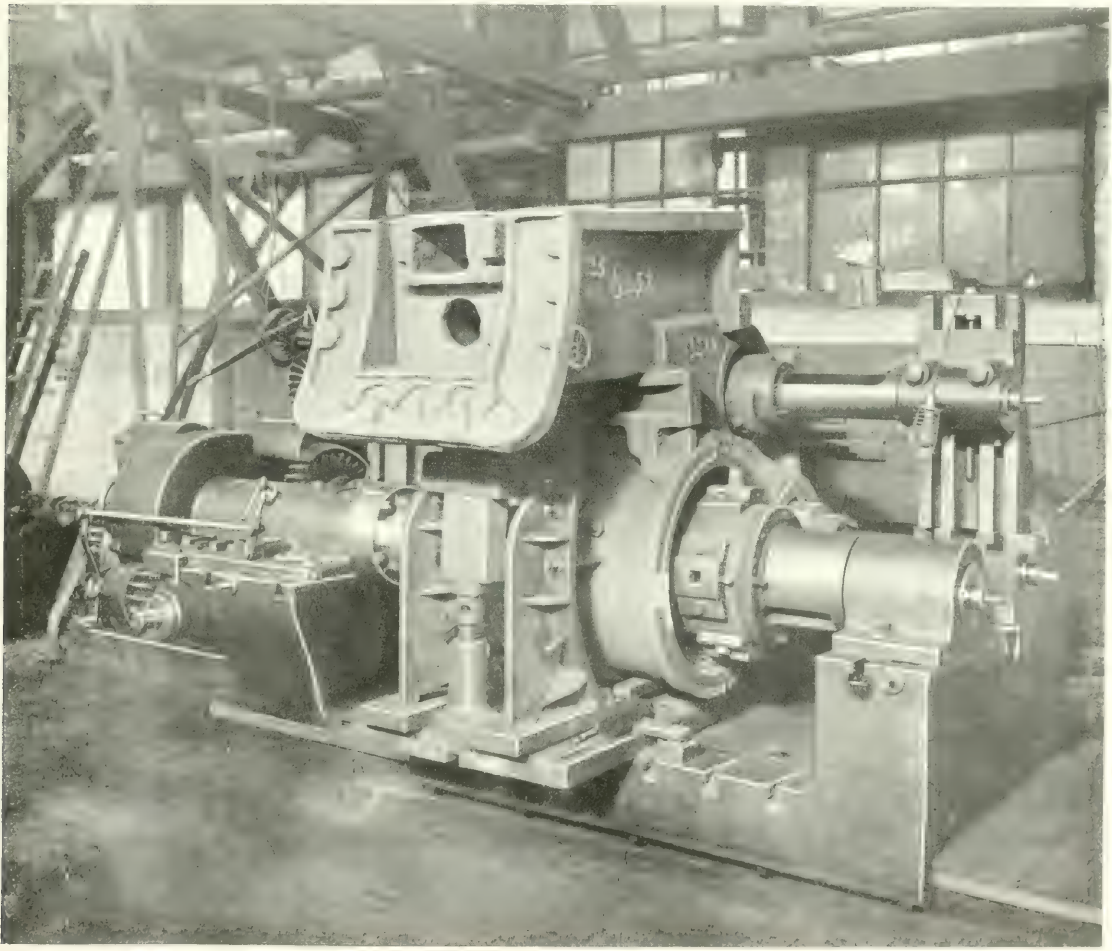
For such heavy traffic engines of enormous power must be built. One American railway after another has held for a short period the record of having the most powerful locomotive in the world. This year the Santa Fé has twice broken the record, first with a 259,800-lb. Schenectady engine, and later with a 267,000-lb. Baldwin. The new Santa Fé engines are tandem-compound decapods. The Baldwin design has a heating surface of 5,390 square feet; its waggon-top firebox is 108 in. long, 78 in. wide, and 80 in. deep. Its boiler is 19 ft. long and 78¾ in. in diameter. It has 463 tubes 2¼ in. in diameter. The high-pressure cylinders are 19 in. in diameter, and the low-pressure 32 in.; the stroke is 32 in. The engine's tractive power is thirty-one tons. These figures tell their own story of the massive design of American locomotives.

THE DEMAND FOR NEW ENGINES.

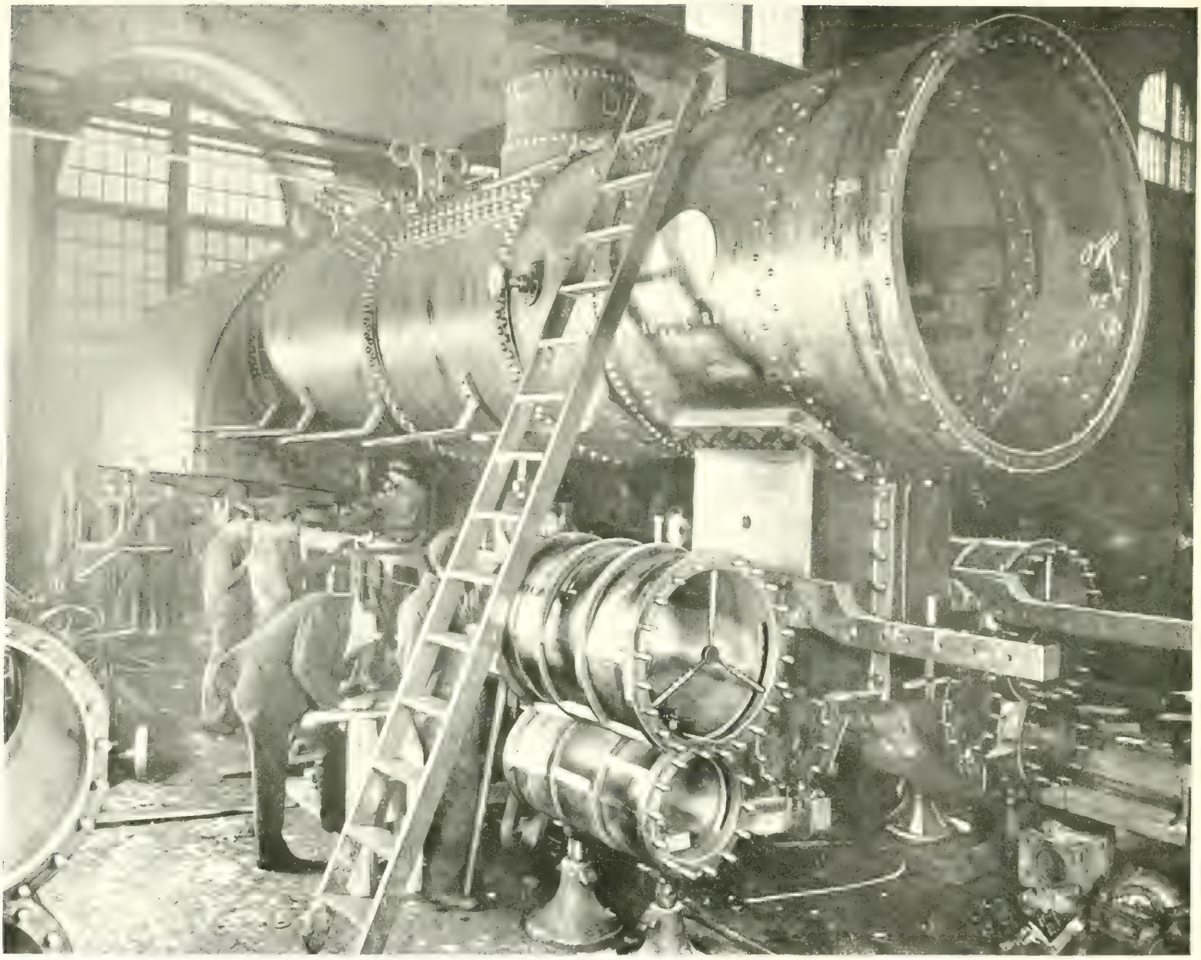
The output of American locomotive shops is now about seventy engines a week—three times what it was five years ago. Half the construction is done in the Schenectady and Baldwin shops, and the rest is divided between six other locomotive shops and the shops of the various railways. The Baldwin output is at present 1,200 engines a year, and the Schenectady output about half this; but the capacity of these shops will equal that of the Baldwin shops on the completion of the extensions now in progress. The great railway development in America during the past two years has flooded the locomotive builders with orders they could not fill, and new shops are to be erected to keep pace with the "boom." The home demand for engines has been so great that American builders have had no time to give to the export trade; and thus the few foreign orders have been unsought; but as soon as the home demand slackens there will be an active American search for foreign buyers.

UP-TO-DATE EQUIPMENT AND SPEEDY CONSTRUCTION.

Nearly all the machinery in American locomotive shops is run by electricity, supplied by a central power-house and fed through the shops to motors, either attached to shafts or directly to the machines. There are no restrictions as to machine output, nor as to the number of machines which may be put in charge of a single workman. Men and machines are pushed to the limit of their capacities. The Schenectady shops, when the writer visited them this year, were employing 3,500 men, at a cost of £1,400 a day, and turning out two locomotives daily. The Baldwin shops employ 8,000 men; they have been running for seventy years, and have turned out more than twenty thousand locomotives. The Baldwin engine and the Pennsylvania Railroad have developed together; the Schenectady locomotive has been fostered by the New York Central. The average weight of American locomotives in 1890 was fifty tons, the average cost £1,600; now the average weight is seventy-five tons, with a maximum weight of 134 tons. The present average price is £2,400, with a maximum price of £3,600; but a locomotive now selling for £3,600 could not have been built for less than £4,500 twelve years ago. The increasing use of labour-saving machinery has greatly decreased the cost of production, despite the steady rise in wages. A standard American locomotive can now be delivered within from eight to twelve weeks after the receipt of the order, although the Baldwin shops have turned out a narrow-gauge



BORING MACHINE—COMPOUND CYLINDERS.



IN THE ERECTING SHOP—LINING UP CYLINDERS. BALDWIN LOCOMOTIVE WORKS.

engine in eight days. The following account of standard locomotive construction, taking the work through the foundry and forge, the various machine shops, and the erecting shop, is a description of the practice in the Baldwin shops, but it differs little from that at Schenectady, Dunkirk, Altoona, Richmond, Providence, and Pittsburg.

THE FOUNDRY.

The cylinder, wheel-centre, and other castings are made in a foundry measuring 80 ft. by 400 ft. The foundry is served by seven jib cranes, erected in a row down the centre of the shop, and two overhead travelling cranes, to assist in handling the moulds and ladles. There are three fifty-ton cupolas, with an actual average daily output of 135 tons. The raw material consists of new pig-iron and old stock. The furnace mixture is in the proportion of 2,000 lb. of scrap, 2,000 lb. of pig, 1,750 lb. of coke, and 50 lb. of marble. Cast-iron is graded by chemical analysis only, and that used for cylinders contains only about $1\frac{7}{10}$ per cent. of silicon. Before using the pig-iron, samples are sent to the laboratory for analysis. The scrap comes to the foundry in the shape of old and spoiled castings, which are broken into small pieces by dropping a heavy weight on them.

CYLINDER CASTING.

One of the cupolas is used exclusively for cylinder iron. The charging is done from a gallery, to which the material is raised in trucks by a crane and an elevator. The operation is started late in the morning by building a coke fire in the cupola, 1,800 lb. of fuel being used to make a bed. About two hours after the fire has been lighted the cupola is filled to the bottom level of the charging door, with alternate layers of coke and a mixture of pig and scrap. An air-blast, produced by a blower driven by a steam engine, is forced into the cupola through two tuyeres, about 5 ft. from the bottom. Half an hour later the cupola is ready for tapping.

Two days previous to the casting, the preparation of the moulds is commenced. The flasks for the large cylinder castings are made in three sections. They are formed of cast-iron plates, bolted together at the corners, and having a trunnion at each end, for handling by the crane. The sand is tamped in the flask on the first day. The cores are put in the next day, and the mould is left in the oven overnight to bake. In the morning the metal is poured. The cylinder-and-half-saddle casting for a tandem-compound decapod weighs 13,000 lb.—as much as an entire locomotive weighed in the early days of the railway. From out of the cupola spout the molten iron flows into a seven-ton ladle. The big ladle is swung to the mould by a travelling crane, and the mould is filled by tilting the ladle with a handle connected with worm-wheels. The next day the flask is opened, and the sand is taken out. By the next morning the cast is cool enough to be cleaned of encrusted scales.

CYLINDER MACHINING.

The machining of the cylinder casting is done with highly efficient machine tools. The work on Vauclain four-cylinder engines is the most interesting. The end surfaces of the casting are first planed off, the casting being set on a planer with the axis of the cylinder vertical, and a cut taken off the end surfaces. The cylinders and the cylindrical steam-chest are then carefully centred by means of gauges. The boring machine bores out both cylinders and the steam-chest at the same time. There are three boring bars, that for the high-pressure cylinder being fixed, while the one for the low-pressure is adjustable horizontally, and for the steam-chest both vertically and horizontally. Each bar has a slot running nearly its entire length, and in the centre of the bar is a screw which rotates independently by means of a separate gearing. The tools are carried on collars, which slip over the bars and have pieces projecting inward through the slots, and taking hold of the screws, so that as the screws rotate the tools are fed along the bars. The collar on the low-pressure cylinder bar is arranged to

INSPECTION ENGINE. BUILT FOR THE PRESIDENT OF THE ST. LAWRENCE AND ADIRONDACK RAILWAY BY THE SCHENECTADY LOCOMOTIVE WORKS, U.S.A.

BOILER SHOP AT THE BALDWIN LOCOMOTIVE WORKS.

carry four tools, and by placing them staggered around the collar four separate cuts are made. As they come from the foundry the cylinders are about $\frac{3}{4}$ in. too small in diameter. Three cuts are taken through the cylinders and the steam-chest, although four cuts are sometimes necessary in the steam-chest. In taking the first cut three tools are generally used on the low-pressure cylinder, and two on the high-pressure and the steam-chest. The second cut, using one tool only, brings the bore to finished size, the finishing cut with a broad tool being little more than a scrape. Before the casting is removed from the machine the end faces of the cylinders are turned up and counter-bored.

After the casting leaves the boring machine, the inner face of the saddle is planed up to match the face of the opposite casting, and the bearings for the front rails of the bar frame are also machined. The work is done on large planers. Jib cranes handle the casting, and there is also an electrical walking crane, with which it is transferred from one part of the shop to another. The cast-iron cylinder heads, which have been previously drilled with holes for bolting them to the cylinders, are clamped into place, and the holes in the flanges of the cylinders are drilled to match those in the heads. The seats of the heads are filed with a fine file, and then ground to a true face to ensure a tight fit. The opening of the steam passage is finished with a concave seat to ensure a tight joint, and the seat for the blast pipe is faced up and finished to a true surface. The two halves are then bolted together. Before the casting is sent to the erecting shop the steam-chest bushing is forced in. The bushing is of hard cast-iron, with walls $\frac{5}{8}$ in. thick. It has circular ribs to match those in the casting, and twelve longitudinal ribs which stiffen it and give the valve a good bearing. The bushing is machined to size with great accuracy, the port openings are finished on a slotting machine. The bushing is forced into the steam-chest under hydraulic pressure. Pressure is applied to the ram by a small hand pump, and the bushing is slowly forced in, the maximum pressure being about forty tons.

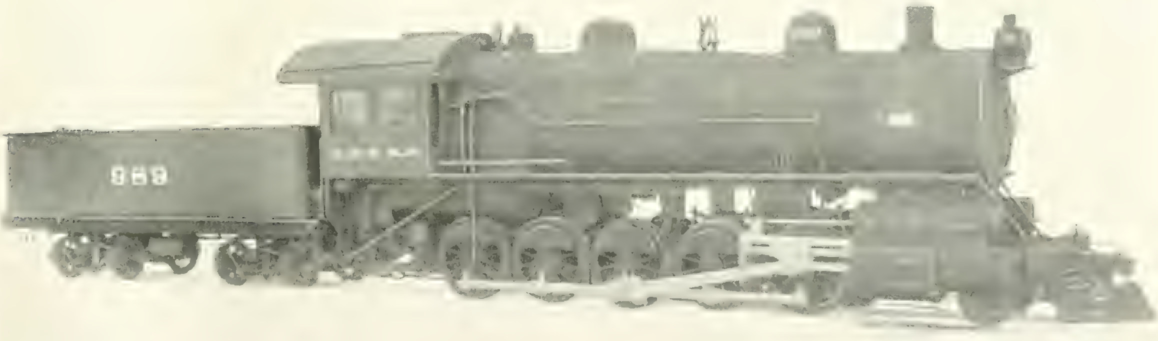
WHEEL MAKING.

Driving-wheel centres for express engines are made of cast steel; for freight engines either cast steel or cast iron is used. If of iron, they are cast in the foundry; if of steel, they are purchased from steel mills. The space for the counter-balance weight is cast hollow. The rim is split in four sections to avoid undue strains in cooling. In the wheel-lathe shop, first the hubs are faced and bored out to size. A keyway is slotted in each hub. The axles, of hammered steel, are in the meantime turned and finished. A keyway to match that on the wheel-centres is cut at each end of the axle, the keyways being at right angles to each other. The bore of the hub has a diameter less than that of the axle by $\frac{3}{1000}$ in. for each inch of axle diameter. The axle is hung between the uprights of an hydraulic press, and one of the wheels is set up in front of it. The end of the axle and the interior of the hub are coated with a lubricant of black lead and oil. Pressure is then applied to the ram and the wheel is forced on the axle. The pressure varies from 10 to 125 tons, the maximum pressure with cast-iron wheels being 10 tons per inch of diameter. Keys are then driven into the keyways at each end and cut off flush. Wrought-iron filling pieces are driven into the gaps in the rims. The pair of wheels is then ready for turning.

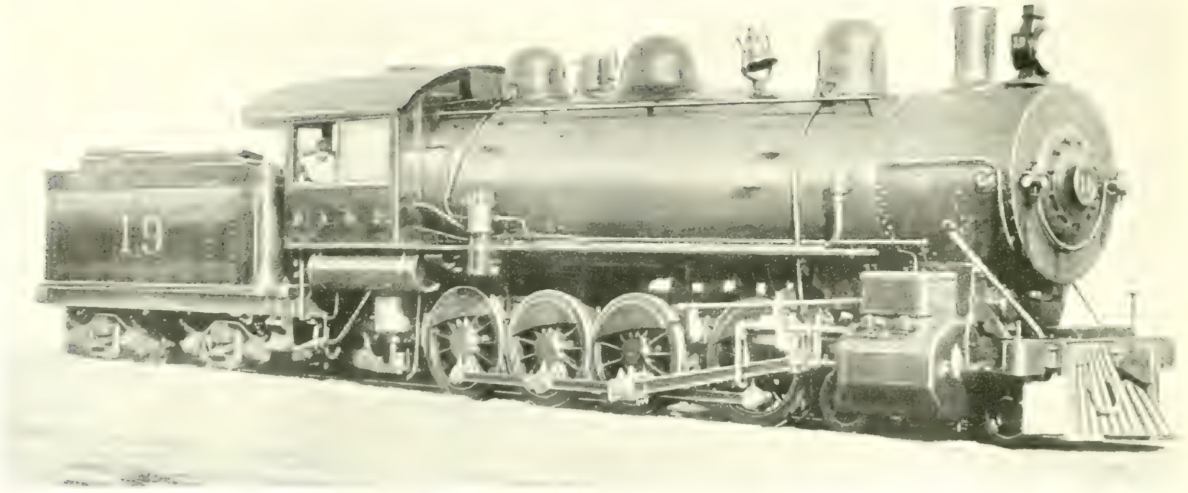
The wheel lathes are driven by separate electric motors. After the wheels have been turned the counter-weights are filled by pouring molten lead into the openings. Lead is also poured over the wedges in the rims. The tyres, made of steel of a high tensile strength, are turned, inside and out, before they reach the shops. An allowance of [illegible] in. per foot of centre diameter is made in boring out the tyres. The tyres are heated in a furnace to expand them. They are slipped over the centres and cooled under a stream of water. For American engines it is not the practice to again turn the tyres after they are shrunk on, but European specifications frequently require this. Finally, the crank pins are inserted. Like the axles, they are of hammered steel. They are forced in under hydraulic pressure.

FRAME FORGING.

The bar-frame is a distinguishing feature of American locomotives. This feature, like the swinging bogie truck and the strain-distributing equaliser beams, gives the flexibility necessitated in engines for pioneer railways, imperfectly ballasted and with many curves. American builders believe the bar-frame will come into universal use. Both wrought-iron and cast-steel frames are used in America, although those of wrought-



TANDEM COMPOUND DECAPOD MOUNTAIN ENGINE. BUILT AT SCHENECTADY FOR THE SANTA FE RAILROAD.



ONE OF SENATOR CLARK'S MASTADONS IN THE MOUNTAINS OF MONTANA. BUILT AT SCHENECTADY.

iron are in greater use. They are forged up from small pieces of wrought-iron scrap. The scrap is hammered into slabs, and these slabs are welded into billets, 3 ft. long and 8 in. square. Above the furnaces is a battery of boilers, and the waste heat of the furnaces raises sufficient steam to supply the whole forge shop. The top rail of the main frame is forged, if possible, in one piece; but in engines of great wheel base the frame is formed in two pieces, which are afterwards welded together. After the two sections of the top rail are forged into shape, the lugs for the pedestals are formed on them. Another hammer in the meantime is forging the pedestals, which are provided with lugs projecting from them at right angles. These lugs have their ends notched V-shape. The pedestals are welded to the top rail. The lugs on the rail and the top of the pedestal are first "scarfed." The under side of the lug is rounded to a convex surface, and a corresponding depression is formed on the upper end of the pedestal. The two are then brought to a welding heat and pounded together under a small steam hammer. After the pedestals have all been forged on, the middle braces are cut to the proper length and their ends pointed to fit into the notches cut in the lugs on the pedestals. The joints are then brought to a welding heat, and the weld is made by blows from sledge hammers. The back brace is secured to the tail piece by a lap weld, its other end being "scarf" welded to the rear pedestal. Then comes the "main" weld. The long section of the frame is notched and the short section is finished with a corresponding point. The two parts are laid together and heated in an open forge. When a high heat has been obtained the end of the frame is struck with a ram, which holds the sections together when they are removed from the fire. The main weld is completed on an anvil by sledge hammering.

Large planing machines, slotting machines, and drills machine the frames. The sides are finished on a plane large enough to work on a pair of frames at the same time, and make a continuous cut from one end of the top rail to the other. The pedestals are finished individually by making short cuts across them. All the inside work is done on heavy slotting machines, the largest of which can work on three sets of frames at once. There are practically three machines on one bed, each driven by an independent electric motor. After the planing and slotting, the frames are drilled in pairs. They are then ready for the erecting shop.

CYLINDER RODS AND SMALL PARTS.

Connecting rods are of hammered steel. In working on the body of the rod, a milling machine cuts a depression at each end, and the body is then finished to size on a large planer.

The planer carries two tools and works on a pair of rods at the same time. The rods are then put on drill presses, and the holes for the brass bushings are drilled out. The circular ends of the rods and all large fillets are finished on milling machines. The oil cups are forged solid with the bed. The bushing for the rods is forced into place on a hydraulic press. The straps and keys for the connecting rods are finished by scraping, and more or less hand-finishing is done on the rods themselves.

The various parts of the link motion are of hammered iron, case-hardened wherever there are sliding surfaces. The pistons are light castings, each being fitted with cast-iron snap rings to prevent leakage. The rods are of iron. The cross-head is a steel casting, the wearing surfaces being covered with a layer of Babbit's metal. Tapered holes are provided for the piston rods, which are held in place by a shoulder turned on them, a large nut being screwed on the outer end of the rod. The eccentrics are of cast-iron. The journal boxes, of cast iron, are finished on large planers, a row of them being set up and worked together. The springs are of high-grade cast steel. The leaves of the springs are assembled and clamped together. The band surrounding the centre is of wrought iron, welded to form a rectangle, and then heated. The shrinkage of the band in cooling binds the leaves together. The hangers and equalisers for the spring rigging are of wrought iron, forged into shape under drop hammers.

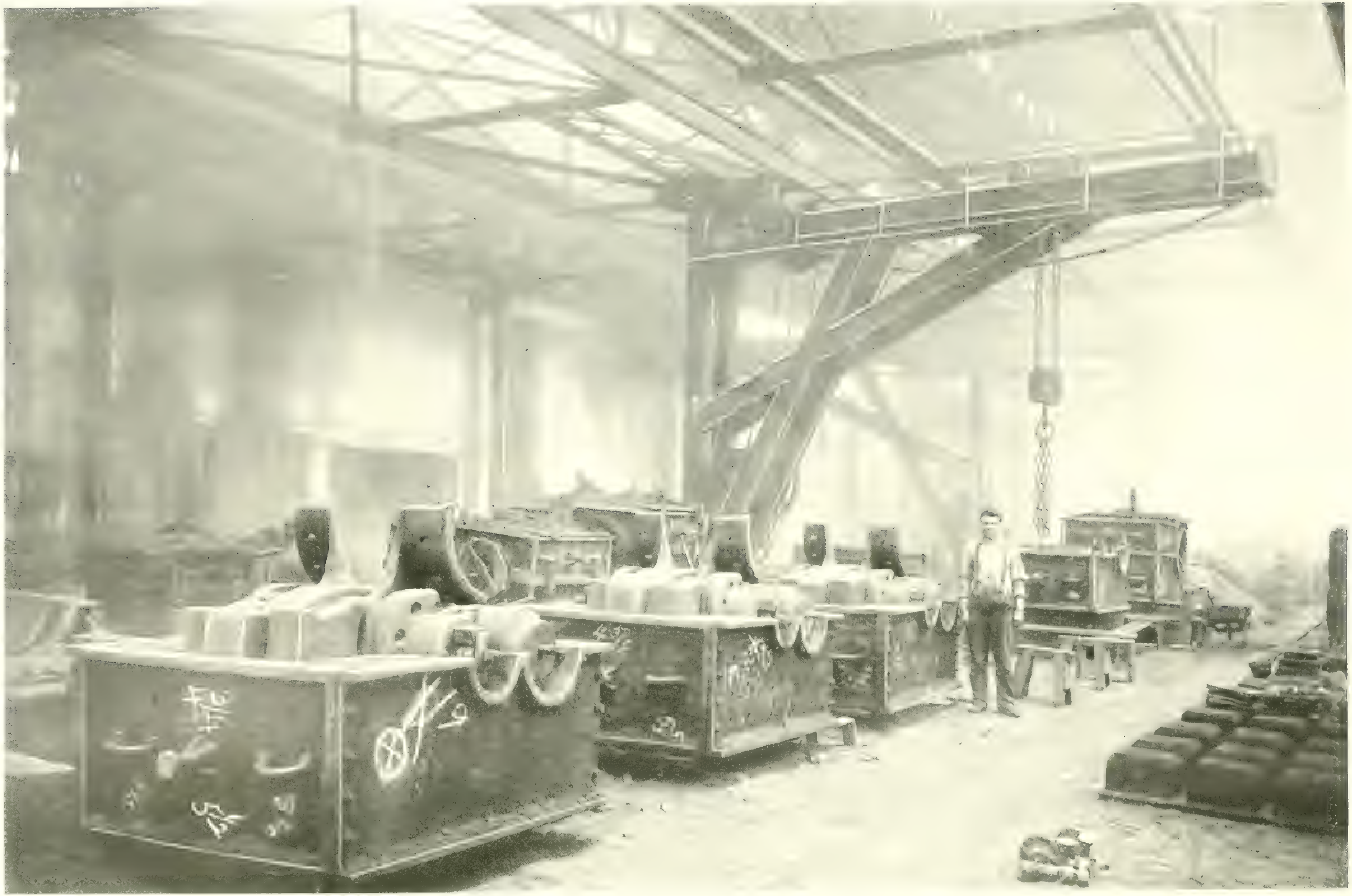
BOILER MAKING.

The boilers of American locomotives have steadily grown in size, until now they can be made little larger without a reconstruction of many overhead structures on the railways. The last engine built at Schenectady for a Western railway had such a massive boiler that its dome top had to be taken off to allow it to pass under some Eastern bridges. Enormous heating surface is sought. On some of the new Eastern express engines the fireman's anxiety is no longer to keep up steam but to keep it down. In American boilers steel is used exclusively, although European specifications usually call for copper fireboxes. In the boiler shop most of the tools are driven by separate electric motors, and the plates are moved about by overhead cranes. The centres of the rivet and staybolt holes are marked out by gauges, and the holes are punched out on punching machines. Afterwards the holes are reamed out to size. On engines for export, the holes are drilled. All flanged plates are annealed, and all flue sheets, after punching, are straightened and annealed before the reaming. The reaming is done with small portable pneumatic tools.

Sheets to be flanged are sent to the flange shop. As far as possible, flanging is done on the hydraulic press. The machine is operated by two accumulators with a maximum capacity of 365 tons. Flanges of odd shape are made by hammering the heated plate on a form with heavy wooden mallets. The roughened edges of the flanges are planed, or, when this is not possible, the edges are chipped with a chisel. The plates for the barrel of the boiler are trimmed in a large shearing press, and the edges are planed on a plate planer. They are then rolled into cylindrical form in heavy bending rolls.

The boiler is then assembled in two parts—the smoke-box with the front rings, and the fire-box outer shell with the rear ring. The sheets are temporarily united with bolts, to be sent to the hydraulic riveters. Each die is placed on top of an upright, and these, in the largest machines, are tall enough to lower the assembled boiler between them, so that the riveting can be started at one end and worked all the way to the other by simply raising the shell, which is hung, by means of chains, from travellers placed under the roof of the shop. The movable die of the riveter is always on the outside of the boiler shell, while the rivet head is formed against the fixed die on the inside. Each machine has its own furnace for heating the rivets. Three men swing the boiler into position and handle the riveter, while two boys watch the furnace and toss up the red-hot rivets.

The inside firebox, the mud ring, and the back head are riveted to the outer shell, and the two sections of the boiler are assembled. The joining seam is riveted by hand, the heads being formed on the outside in a die which is struck with heavy hammers. The staybolt holes are threaded with small portable pneumatic tapping machines. The staybolts are



VIEW OF FOUNDRY. BALDWIN LOCOMOTIVE WORKS.

of iron, threaded at each end, the middle being turned down to the inside diameter of the thread. In the centre of the bolt is a small hole, through which leakage occurs when the bolt breaks. On the outer end of each bolt is a square end, by means of which it is screwed in. The head is then cut off by machine, and the bolt is hammered down cold at each end. The firebox is usually radially stayed all around, although occasionally the crown sheet is still supported by means of crown bars and sling stays. For the export trade the staybolts are usually of copper. The dome, in the meantime, has been riveted to a flanged ring of pressed steel, previously united with the shell by the hydraulic machine. The body of the dome is of boiler plate; the dome top and base ring are of pressed steel. As the plates are assembled, the sheets are caulked at the points to prevent leakage. This is done with a tool with a rounded edge, which forms a fillet and pinches the plates together tightly without cutting them.

ERECTING SHOPS.

The last five or six days of the construction of an American locomotive are spent in the erecting shop. In the Baldwin erecting shop, which is served by cranes of 50 and 100 tons capacity, there is space for the erection of seventy locomotives at one time. The cylinders are first set up. They are placed on jack screws at about the height above the ground they will stand in the finished engine. The upper surface of the saddle is chipped off by hand to ensure a good fit for the smoke box. The engine frames are then erected and lined up. Then the boiler is lifted by one of the cranes and placed in position. The boiler is bolted to the saddle. The tubes are inserted and expanded by means of a special tool. They are of iron and have a copper ferrule at the firebox end to ensure a water-tight joint. The boiler is secured to the frames by means of a heavy bearer in the form of a girder, which is bolted to the mud ring on both sides, at the middle length the firebox. The front and back water-legs are also secured to the frames by means of steel plates. The driving wheels are set up on a track, and the boiler and frames are swung over them. The throttle pipe, with its valve, is lowered through the opening in the dome ring and secured to the dome. The other boiler fittings are put in place.

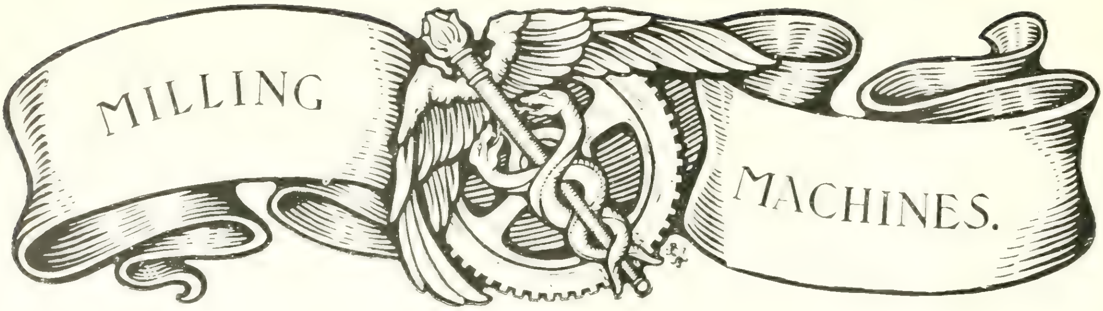
The water test is then given the boiler. Water is forced in the blow-off cock until the pressure is one-third greater than the working steam pressure. As the leaks develop the caulkers work on the seams. Then follows the steam test, at a pressure one-tenth greater than the working pressure. The wheels are next lined up, the connecting rods set up, the link motion assembled, and the valves set by means of trams until they show the amount of lead desired. After this the eccentrics are keyed to the main axle. The boiler is lagged with magnesia and encircled with wire hoops, to which the lagging is fastened with cleats. The sheet-iron jacket is placed over the boiler and the cylinders are lagged and jacketed. The cab is placed in position. The boiler is then connected to a stationary steam plant, and the engine is given three running tests—one with reverse lever in back gear, and two with the lever in forward gear. The truck is rolled into place, and its springs are equalised with those over the front axle by a heavy equaliser lever. The grate, ash-pan, and remaining parts are set up, and the engine is ready for the road.

The tenders are built in a separate building, one floor being devoted to the construction of trucks and frames; another to the laying out of plates, and shearing and punching them; a third to erecting. Tenders for the large engines weigh, when loaded, about fifty tons.

All material that enters the shops is tested chemically and physically in the testing-room. By the careful system adopted of numbering every plate in every boiler, it is possible, in case of a boiler explosion, to refer to the test and obtain full data regarding the plate.

THE EXPORT TRADE.

American locomotive shops are now working night and day to catch up with the home orders that have been pouring in since the beginning of the industrial boom following the Spanish war. The capacity of the shops is being doubled. When they are able to supply the home demand they will undoubtedly reach out for export trade.



MILLING MACHINES.

BY

JOSEPH HORNER.

Treats of the Heavy Milling Machines, which resemble Planing Machines in their general construction.

VII.

AMONG the latest developments in machine tools are the heavy milling machines which are built broadly on the planer type. All the early milling machines were of small dimensions, were lightly built, and designed only for those classes of work for which Lincoln and Universal machines are still chiefly used. A great change came with the introduction of the planer type, with a cross rail on housings, carrying vertical, or horizontal spindles and arbors, and a long bed on which the work is traversed beneath the cutter. The term "plano-miller" is often applied to this type, and also "slabbing machines," the latter term being of more general use in American shops. The question of spindle arrangements and their details is a secondary one, but, in strictness, a horizontal spindle is generally understood by the term plano-miller. The main feature of all these machines is that the table is long, and has a long traverse by comparison with the tables of Lincoln millers. They are, therefore, both in their build and in the dimensions of the work done upon them, the present rivals of the planing machines, after the patterns of which they are built.

HEAVY PLANING *v.* MILLING.

The important questions of degree of accuracy and of smoothness of finish produced on the common planer, and on the plano-milling machine cannot be settled in an absolute manner. Differences of opinion exist among managers with regard to these matters. But the writer's experience is this; that the differences which exist are, in the main, those due to good, bad, and indifferent machines, and conditions of practice, rather than to anything of an absolute character. You may have good, bad, and average practice either in planing, or in milling, and those whose experience has lain in one class alone will thus have their opinions biassed. There is no man more dogmatic than a workman whose practice has run in one narrow groove.

The conditions which are essential to good results, both in planer and miller, are—absolute rigidity of framework, proper formation and fixing of the cutting tools, and general handiness. In the absence of these, neither machine will prove economical, and the marks of vibration and chatter will be apparent both in heavy and in light finishing cuts. On planer and miller alike, broad finishing cuts will show lines and ridges that look unsightly even if they do not matter so much in regard to fitting, as in the case of the rougher classes of work, and in work that has to be ground afterwards, or in which the surface is tooled for good appearance only. But it is not good economy to retain any machines that cannot be depended upon to produce good results without lessening the depth of cut to a microscopical amount. Even if work may be left rough, or if it has to be ground or scraped, the

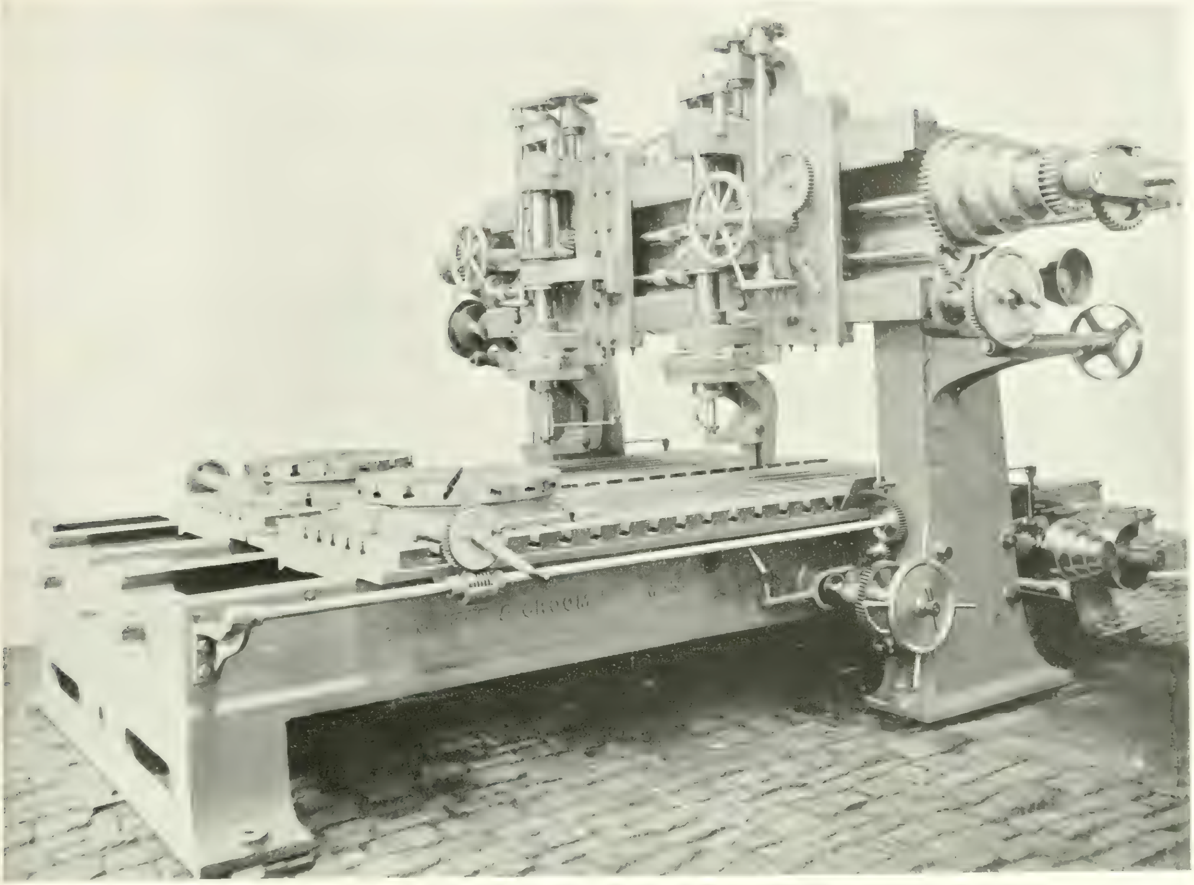


FIG. I. PLANER TYPE OF MILLING MACHINE, WITH DUPLEX OR COMBINED ARRANGEMENT. MESSRS. CUNLIFFE AND CROOM, LTD., MANCHESTER.

milling machine or the planer should be capable of taking a broad slogging cut without any very perceptible chatter.

But in the more intelligent and eclectic practice of the present day the two machines often become mutually helpful. It is difficult to mill very broad surfaces quite accurately on account of the springing of the long arbors, which cannot be entirely eliminated. Yet the advantages of dealing with broad surfaces at a single traverse are so great, from the point of view of economy and approximate accuracy, that it is very desirable to be able to substitute the broad cutter, or gang of built-up cutters. for the single-edged tool. And so we frequently find that broad surfaces are roughed out with gang cutters, and finished on the planer with a single-edged tool. The great objection to this is the necessity for moving and resetting the work, which is a thing to be avoided, unless in cases where the advantages gained outweigh the loss of time involved in resetting.

One of the incidental advantages of the heavy miller, with long table, over the planing machine is, that while one object is being cut, another, or several, can be undergoing the process of setting. Facility for this is afforded by the very slow movement of the table. In a few machines the tables are duplicated, which again gives fuller advantages. (See fig. I.)

MODIFIED TYPES OF PLANO-MILLERS.

The utilities of the plano-milling machine when brought into rivalry with the planing and shaping machines, using single edged tools only, are so apparent on some classes of work, that the inevitable result has been that from simple types, other and more complex machines have been, and are still being, derived, with greatly extended ranges of capacity.

The planer type of machine is modified in the following ways: Spindles and arbors are either vertical, or horizontal. Sometimes the cross rail is omitted, and two spindle heads slide upon the faces of two housings. Each housing has a horizontal adjustment along the wing beds that flank the main bed. The heads are elevated or lowered simultaneously by vertical shafts and gears, the motion of which is derived from a horizontal shaft. Here the resemblance to the Lincoln machine is very close. Many machines which belong properly to the class of plano-millers combine vertical and horizontal spindles. Many again are open-side machines, either temporarily converted, or of the permanent open side type, that is where one housing is entirely omitted, and in which the vertical spindle or spindles are carried on an arm that overhangs from one housing, upon which it has vertical adjustment. The same upright may carry a horizontal spindle as well. These machines fulfil similar functions to, and possess the same advantages as the open-side planers. One modification of this design resembles the pillar and knee machines. Instead of housings, an arm is bolted upon the top of the pillar, carrying vertical spindle heads on its face. The outer end of the arm is supported by a bracket attached to the outer end of the knee. The most complete types include both horizontal and vertical spindles, for performing simultaneous or separate sets of operations. In these combined

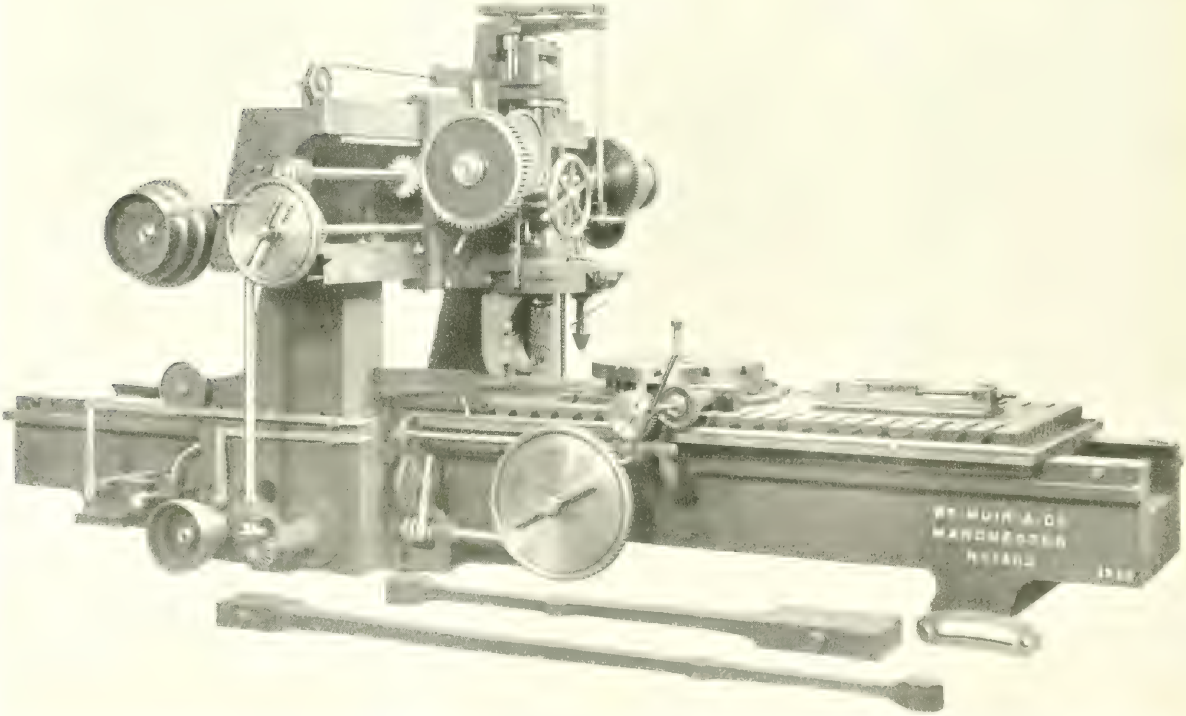


FIG. 2. HEAVY MILLING MACHINE.
WM. MUIR AND CO., LTD., MANCHESTER.

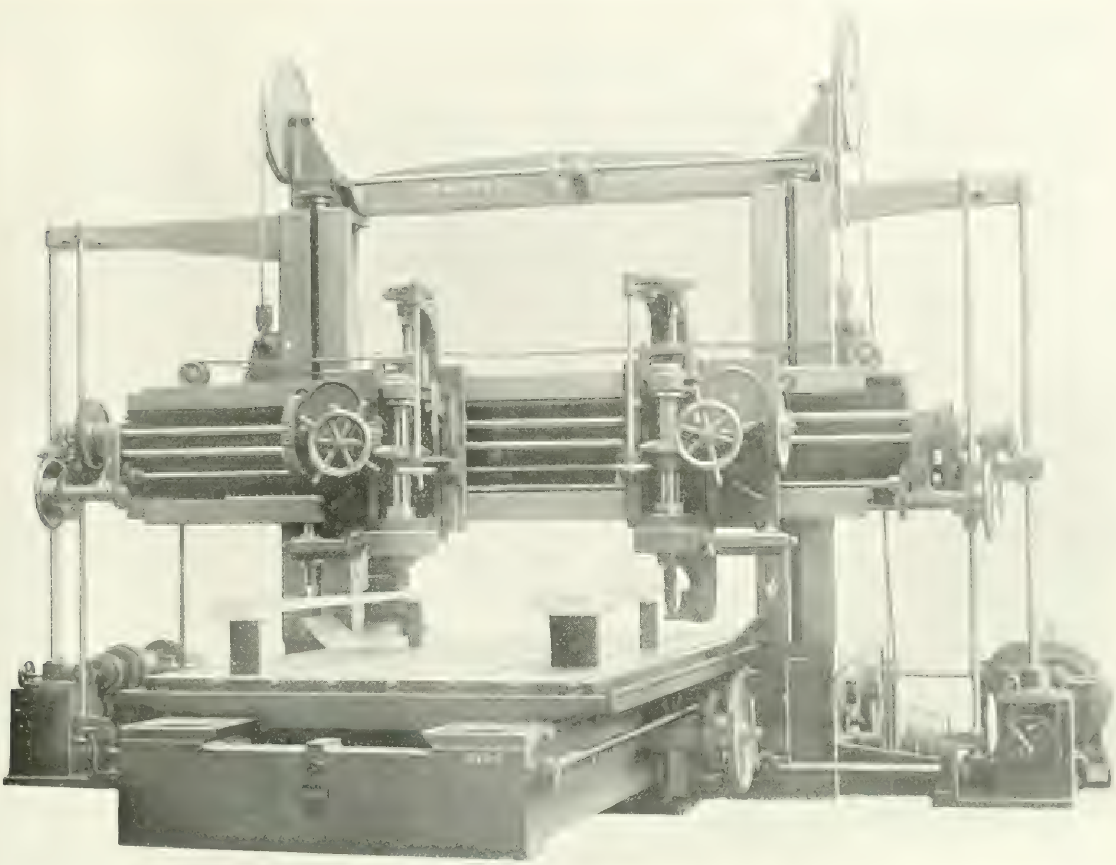


FIG. 3. A MILLING MACHINE OF FIFTY TONS WEIGHT.
WM. MUIR AND CO., LTD., MANCHESTER.

machines the saddles for the vertical spindle or spindles are carried on the cross rail, and those for the horizontal spindle on the vertical faces of the housings. They are usually independent. In some machines they can be united to move vertically as one. Frequently two vertical spindles are fitted to the cross rail, making four spindles in all, capable of simultaneous operation, two on faces, and two on edges—in this feature resembling closely the four-headed planing machines; and, of course, edge mills, or face mills can be used on either vertical or horizontal spindles. These are the main features of such machines. The variations in types necessarily modify details, besides which the designs of different manufacturers are marked by considerable differences.

The leading features which should characterise a high class plano-miller are the following: A wide range of feeds for the table. In heavy milling, from 3 in. to 4 in. a minute may be taken as a suitable mean. Slower feeds are sometimes required, and others considerably higher, up to 8 in. or 10 in. a minute for fine finishing. The table is capable of adjustment by hand for setting work. It should also be adjustable by power in either direction, usually at a rate of about 30 ft. per minute. The cutter speeds range from about 6 to 40 revolutions per minute, variable through eight changes or more. The mass of the cross rail is, in most cases, counterbalanced, and is capable of vertical adjustment by hand or power, to graduations in thousandths of an inch, or by metric [illegible]

The spindle head has a certain amount of adjustment by hand along the cross rail, and also vertically, by fine graduations. By this last, the exact depth of cut is regulated, after the cross rail has been set approximately.

No very exact classification of machines of the planer type is possible beyond that just outlined, since they vary so much in detail, and have, in the hands of various makers, become so highly specialised as will be seen from the illustrations. These variations render necessary a somewhat hard and fast classification if we are to give a representative selection. It will therefore be convenient to take the vertical spindle machines chiefly in this article, leaving most examples of the horizontal spindles and composite machines for treatment in another.

DUPLEX MACHINES.

A very advanced machine is shown in fig. 1, by Messrs. Cunliffe and Croom, Ltd., of Manchester. It is a duplex miller, in which the tables can be run in unison or separately. The tables measure 10 ft. in length by 3 ft. 6 in. in width, and the distance between the uprights is 8 ft. There are also two circular tables, removable, of 2 ft. 6 in. diameter. Everything is massive, as required for heavy marine, locomotive, and general work. It weighs 20½ tons. The range of operations which can be done on such a

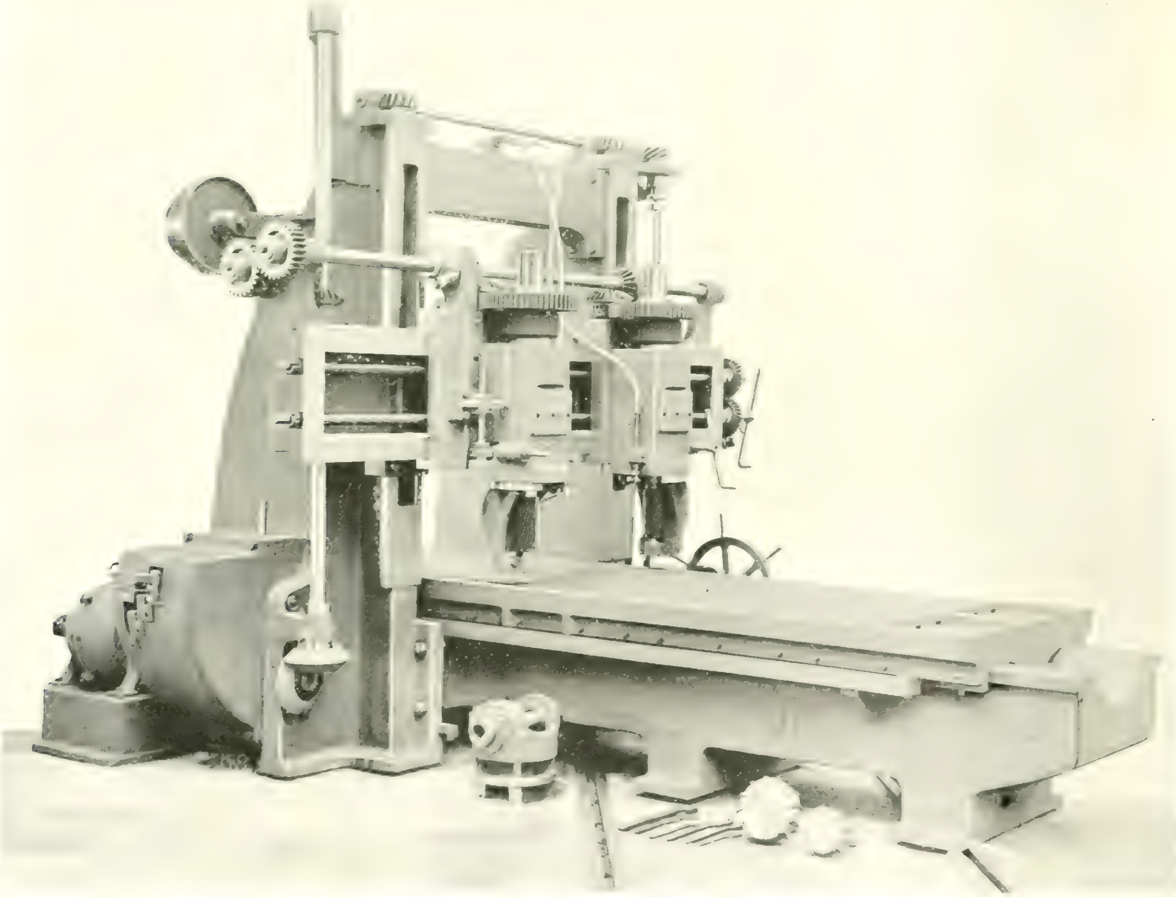


FIG. 4. UNIVERSAL PLANO-MILLING MACHINE, KENDALL AND GENT, MANCHESTER.

machine is very extensive. The two rectangular tables render it more adaptable than a single wide one. In the latter case, a small piece will often have to monopolise the table, leaving a large area unoccupied. Or if dissimilar pieces are put on, it may not be possible to arrange one speed and feed adapted alike to each. But with two independent tables, and heads, each with its own variable feeds and speeds, this can be readily done; and the advantages of the broad table for large masses are still secured by coupling them. Another advantage is, that one table may be running, carrying work being tooled, while the attendant is setting work on the other table.

Again, such pieces as bossed levers and connecting rods, which have had their webs tooled parallel on the long tables, can have their ends finished on the circular tables. The feeds of the rectangular tables are self-acting and variable, and they have a quick return in both directions by power. The movements of the circular tables are also self-acting through worm gear.

The spindles on the two heads are driven through double gear. But when light cuts only are wanted, or when milling brass, the back gear is thrown out. The lower ends of the cutter arbors are supported with a bracket when edge milling is being done. This bracket can be swivelled. The spindles run in conical bearings. Each head has its own independent driving, feed, and reversing motions.

In a three-spindle machine of another design by the same firm, carrying three vertical spindles, and weighing 13 tons, the table is nearly square, measuring 7 ft. long by 6 ft. wide; the machine being designed chiefly for broad face milling. Each spindle is driven from a single splined shaft, having its bearings above the cross rail. The latter has vertical adjustment on the uprights, and the spindle heads each have separate horizontal adjustments along the rail. The central head has a self-acting horizontal feed along the rail. The vertical adjustments to each spindle are by hand. The spindles are 4½ in. diameter. The table has four changes of feed, through gears enclosed in a box, and a quick return by power.

SOME MASSIVE MUIR MACHINES.

A very fine example of a heavy milling machine by Wm. Muir and Co., Ltd., of Manchester, is illustrated in fig. 2. It is treble geared, its spindle measures 4 in. in diameter, its bed is 18 ft. in length, the rectangular table measures 12 ft. by 4 ft., its circular table is 2 ft. 6 in., and the machine weighs 13 tons. Samples of work done upon it are seen in the connecting rods, and slot link, lying on the ground. It is rendered adaptable to a wide range of general work by the inclusion of a profiling attachment, which, of course, does not affect its usefulness for plain milling.

Some of the principal details are as follows: The bed contains a cistern for the lubricant, of soap and water, which is forced up to the cutters by a centrifugal pump, and the table has a trough round its outer edges to receive the lubricant after use, whence it drains back to the cistern in the bed. The motions of the table are self-acting in each direction, with automatic reversal. Provision is made for a quick traverse by power also, and there is also a hand feed motion. The feeds range from ½ in. to 3 in. per minute. The rotation of the circular table is self-acting by worm gear. It is, of course, removable.

The rigidity of the spindle head is ensured by making the cross rail and uprights in one massive casting, of boxed pattern, and by making the bearing surfaces of large area. The transverse movements of the spindle head are variable, and self-acting; the reverse is also automatic, and each movement can be hand-operated. The range of the horizontal motion of the spindle in this machine is 4 ft. 11 in. The slide which carries the spindle has a vertical adjustment of 12 in. by hand wheel and screw. Much care is taken in the fitting of these parts. The spindle runs in conical bearings of gunmetal, with lock nuts, and an adjustable tail pin of steel. Indexed steel rules are fitted, both to the rectangular table, and to the vertical transverse slides, and the circular table is graduated. The profiling attachment is capable of shaping objects measuring up to 12 ft. in length, by 18 in. in width and 5 in. in depth. Cutters ranging from 2 in. to 18 in. in diameter can be used, each running at suitable speeds.

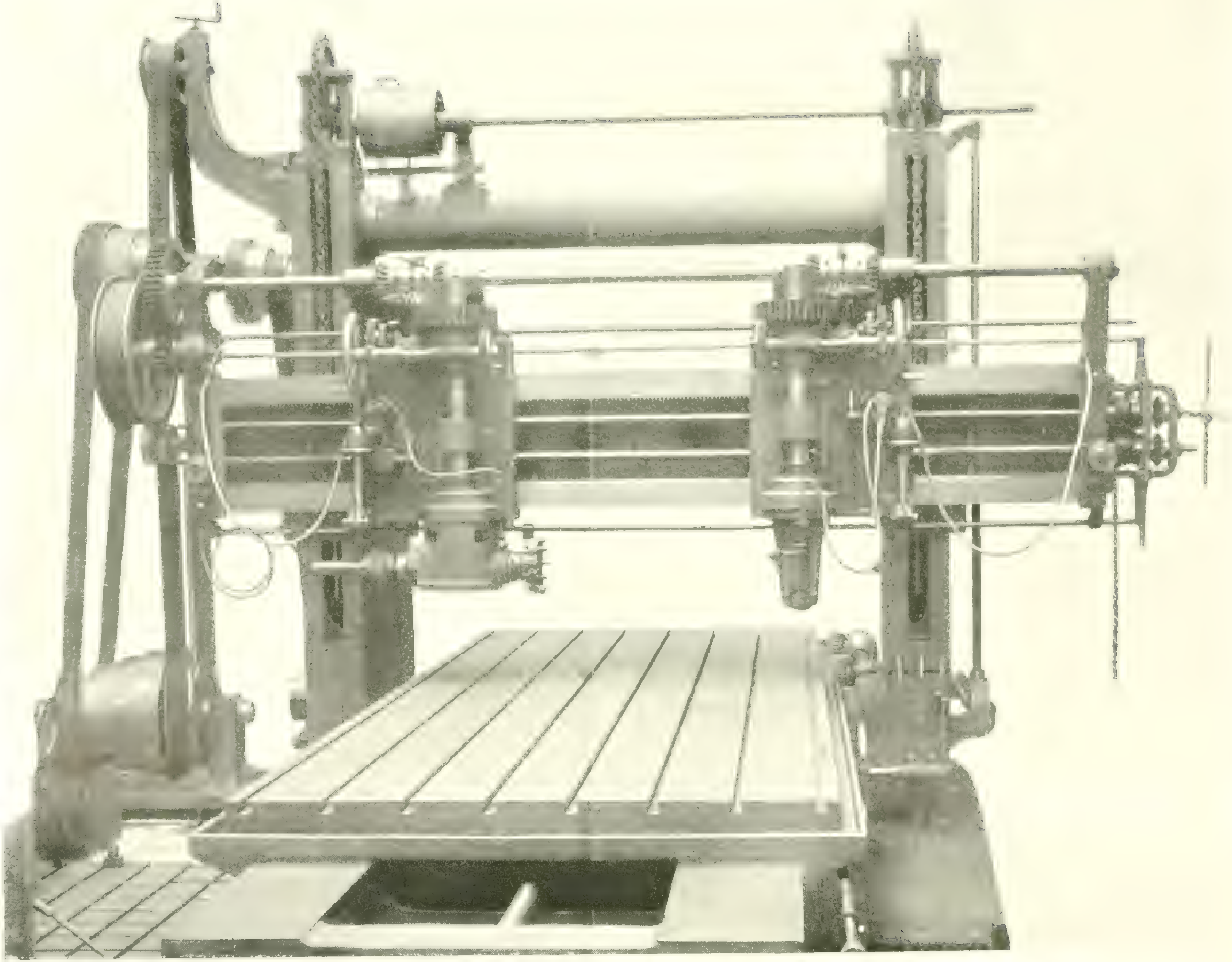


FIG. 5. UNIVERSAL DOUBLE-HEAD MILLING, PROFILING, BORING, AND DRILLING MACHINE.
JOHN HETHERINGTON AND SONS, LTD., MANCHESTER.

A MACHINE OF 50 TONS WEIGHT.

A more massive machine by this firm, recently completed for a large railway company, is shown in fig. 3. Some idea of its proportions may be gathered by noting that the distance between the uprights is 8 ft., that the spindles are 4 in. in diameter, and that the weight is 50 tons. Each spindle is driven independently by its own electric motor, and each can be used as a profiler, as well as for plain work.

A MACHINE RENDERED UNIVERSAL BY THE ADDITION OF A SUPPLEMENTARY SPINDLE.

Fig. 4 illustrates a machine by Messrs. Kendall and Gent, of Manchester, in which, in addition to the two vertical spindles, there is a supplementary horizontal spindle fitting ; seen lying on the ground. This can be set to any vertical angle, and so renders the machine universal as regards angular work. The driving is by a motor at the rear end ; and changes of feed are effected by a nest of gears contained in a box in front of the motor. A length of 10 ft. can be milled on the table of this machine.

The rates of feed for the various steps on the cones are read off on an index plate. The lower bearing of each spindle has a vertical fine adjustment for putting on the cut, when using face mills. The traverse of the spindle carriage is self-acting in each direction, and it has hand movements also. The same remark applies to the table feeds. Graduated rules and pointers are fitted, and pump, tanks, and fittings for lubrication.

A UNIVERSAL MACHINE WITH BORING AND DRILLING MECHANISM.

Fig. 5 illustrates a heavy universal machine of rather special type, by the firm of Messrs. John Hetherington and Sons, Ltd., of Manchester, of which they manufacture several varieties. This example is designed more particularly for dealing with heavy engine work, dynamo and motor castings, crane castings, etc. It combines horizontal and vertical milling, profiling, boring, and drilling. The spindle heads are made right and left handed, the spindles approaching towards the inner edges, a device which is adopted to enable them to be operated closer to each other than when they are placed centrally on their sliding carriages. Another feature is the fitting of a horizontal spindle to the left hand head, or to both, if required. This permits of the facing of a vertical edge or edges without having to reset the work, and without the extra expense of having separate heads for horizontal spindles. In the case of engine cylinders and beds, of some connecting rods, and other parts where faces occur at right angles, the supplementary spindle is most advantageous.

The movements of the spindle carriages are by hand or power. The spindles are of 5 in. diameter in the machine shown, and are double and treble geared. They run in double coned bearings of gunmetal, with provisions for taking up wear. The bottom bearings slide on their carriages, and have self-acting and hand-operated feed motions through change wheels, to adapt them for drilling and boring. Each spindle has a range of movement covering the whole breadth of the table. All the essentials of a high class machine are embodied, such as independent automatic disengaging motions to the cross feeds of both spindle heads, variable cross feeds, counterbalanced cross slide, steel rules fitted to the uprights, to the cross slide, and to the spindle slides ; pump and connections, trough round the table, automatic table feeds with adjustable stops, cut gears, belt tightening device, etc. Each head is also fitted with a guide spindle for profiling. The combination of so many features in one machine, in which, by the way, the utility of neither one is lessened, or weakened, renders it of especial value in general engineer's shops. On a single piece, horizontal and vertical faces can be tooled, holes drilled or bored, and portions profiled, all at one setting, without disturbing or shifting the work. It is capable of profiling work up to 20 ft. in length, by 1 ft. 6 in. in breadth and 1 ft. deep.

SPINDLE DETAILS.

The very perfect provisions which are made for the various movements of the spindle, and to ensure the durability of the fittings of its various parts are illustrated by the sectional drawing in fig. 6, in which the spindle and its head are shown in relation to the cross slide A. All the fittings except the main castings are either of steel or gunmetal.

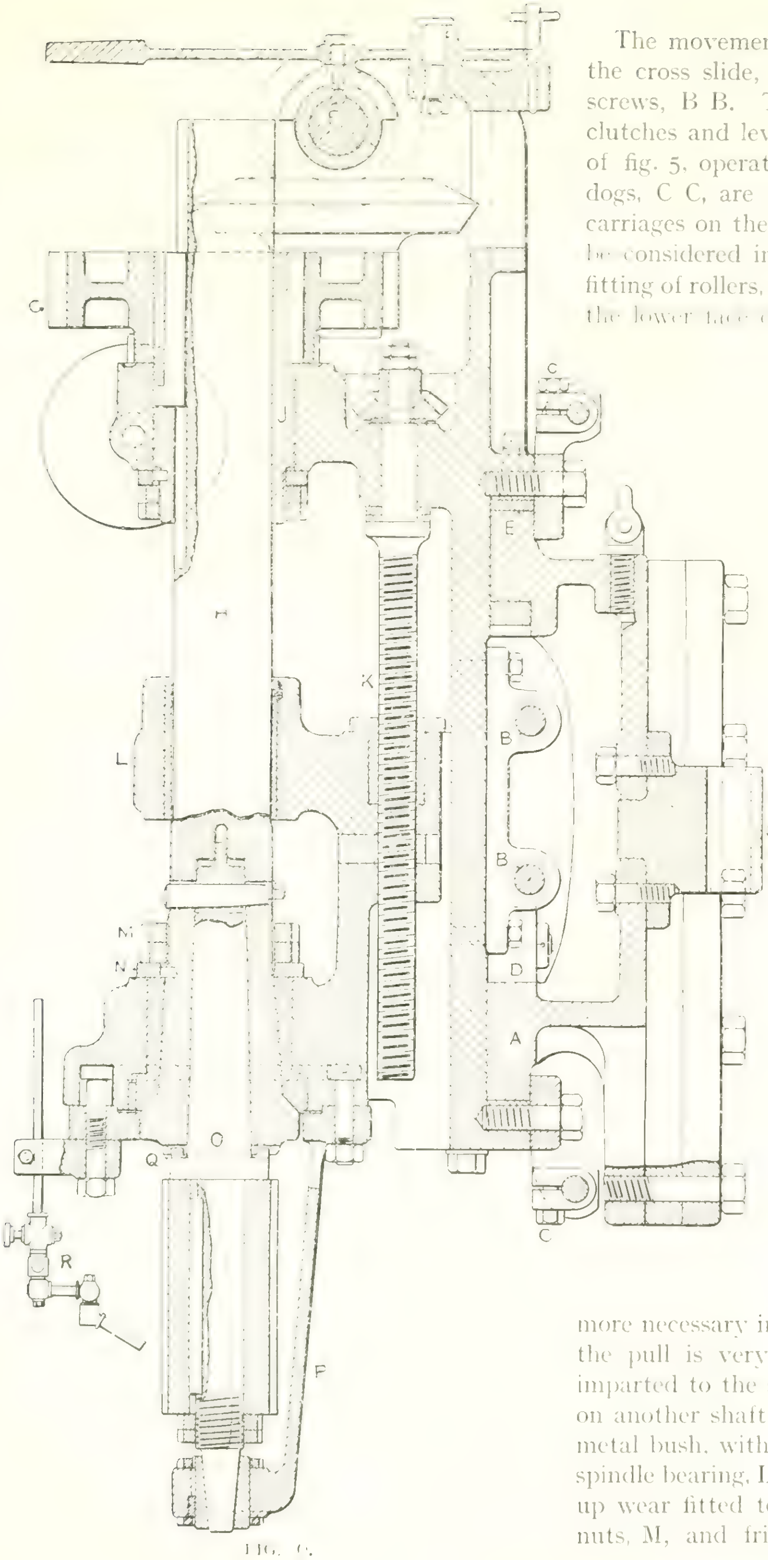


FIG. 6.

The movements of the two spindle heads on the cross slide, A, are derived from the feed screws, B B. These are tripped by means of clutches and levers, seen at the right hand end of fig. 5, operated from the rods on which the dogs, C C, are adjusted. The friction of the carriages on the cross rail, which is a matter to be considered in profiling, is minimised by the fitting of rollers, D, running on the inside edges of the lower face of the cross slide, besides which the take-up strips, E, on the upper edge of the slide are of gunmetal. Each milling spindle is driven from the horizontal shaft, F, whence a nest of bevel wheels, with a clutch reversing motion, slid to right or left by the lever seen above, drive to a pair of spurs; the larger one of the latter, G, driving the spindle, H. It must be noted, however, that this wheel does not fit directly upon the spindle, but on an intermediate sleeve, J, so that the latter, which runs in the bearing, thus takes the strain, relieving the spindle of it. If the wheel, G, were sliding directly on the spindle, the pressure of the driving would push the spindle against one side of the bearing, and quickly spoil it for accurate milling. The pressure, however, coming on the sleeve, J, preserves the spindle; and this precaution is also even more necessary in belt-driven spindles, in which the pull is very severe. The vertical feed is imparted to the screw, K, through bevels above, on another shaft; the screw running in a gunmetal bush, with adjustable nut, in the bottom spindle bearing, L. The arrangements for taking up wear fitted to this, comprise the steel lock nuts, M, and friction washer, N. The double
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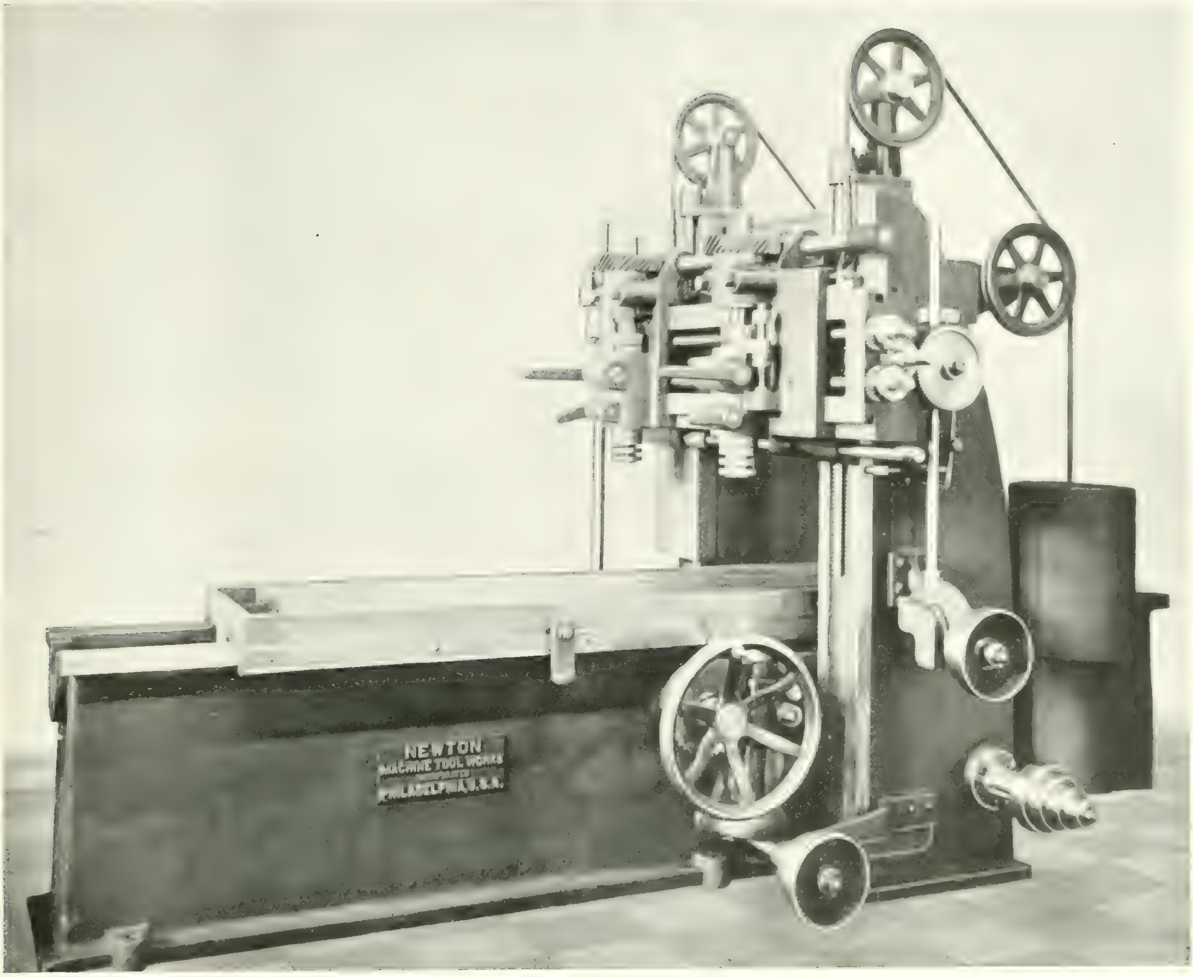


FIG. 7. VERTICAL SPINDLE MACHINE.
THE NEWTON MACHINE TOOL WORKS, OF PHILADELPHIA.

coning of the neck, in the most approved lathe fashion, will be noted, designed with the object of preventing the risk of the spindle seizing in its bearing, which is further rendered improbable by a gunmetal bushing, and by an oil groove around the washer, N. Wear of the faces of the wheel, G, and boss, above, is taken up by means of similar lock nuts and washer. The arbor, O, has a taper shank, of 1 in 20, and is secured to the spindle nose by the tongue at its end, and a cottar with screwed tail. To further assist the driving, and to relieve the cottar of strain, claw-shaped jaws, Q, are cut on the end of the main spindle, and these engage with claws on the arbor, so that the drive is as close as possible to the cutter. The lower end of the cutter arbor is supported in a gunmetal bush, with adjustment for wear, the end and the bush fitting by a taper of 1 in 6. This bush is carried and adjusted in the swivelling stay, P.

SPINDLE DRIVE THROUGH SPIRAL WHEELS.

The machines manufactured by the Newton Machine Tool Works, Incorporated, of Philadelphia, Pa., are mostly of a massive character, chiefly for slabbing work. One of these, with two vertical spindles, is shown in our illustration (fig. 7). Here the spindle drive is effected very smoothly through spiral or angle wheels. A length of 8 ft. can be milled on this.

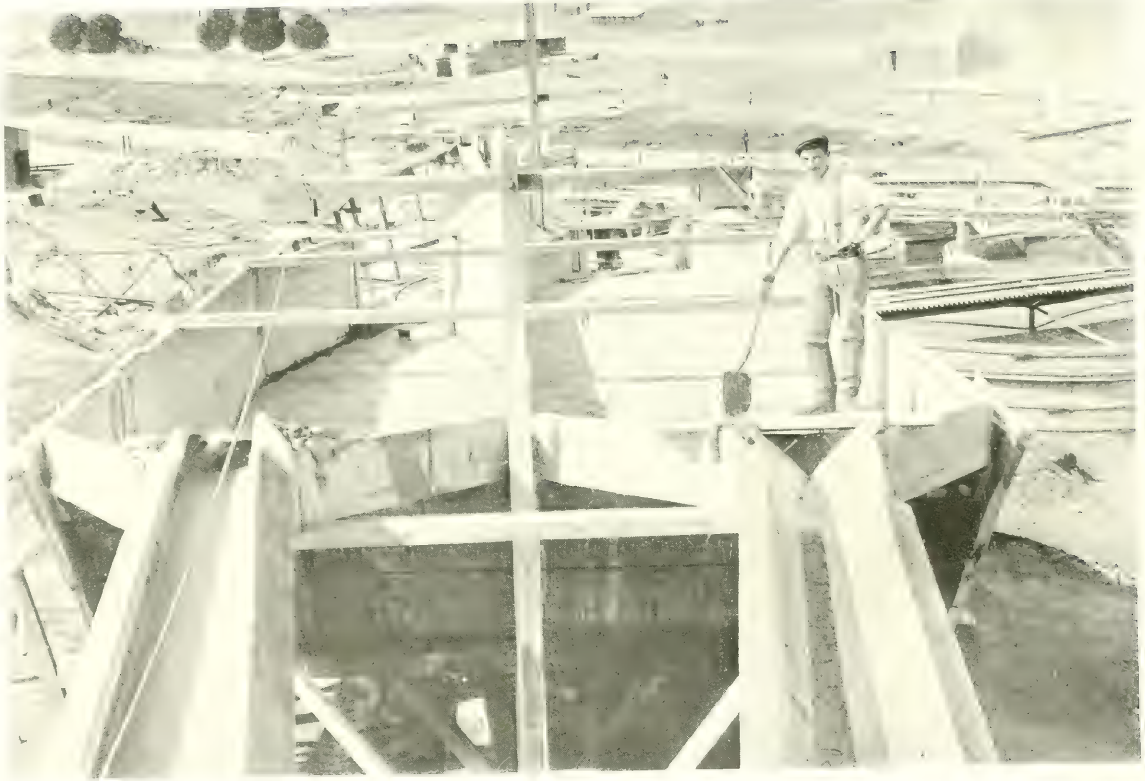


FIG. 3. SETTLING TROUGHS AT THE MEYER AND CHARLTON MINE, JOHANNESBURG, FOR COLLECTING ROUGH CONCENTRATES WITHOUT THE USE OF PRESSURE WATER.

COLLECTING PYRITIC MATERIAL FOR CYANIDE TREATMENT.

BY

EDGAR SMART.

This article is supplementary to the author's papers on "Developments in Cyanide Practice," which appeared in the July and August issues of the Magazine.

IN the first issue of this magazine reference was made to the usual methods employed on the Rand goldfields in the preliminary classification of battery pulp for cyanide treatment, including the separation of a rough concentrate by means of spitzlutten.

SPITZLUTTE PRACTICE.

The first photograph shows a set of six of these in series, through which the pulp from the battery is passed successively, after which the greater part of it passes away to the sand-collecting vats by the upper launder shown on the left-hand side of the picture. Each spitzlutte is made a little wider than the preceding one, so that the velocity of flow becomes less in each, and a somewhat different product is obtained at each succeeding discharge orifice. These products are not, as a rule, separately treated, but are either put into one vat or grouped into two grades for treatment. The principal object of the use of several spitzlutten is not so much the production of many grades of coarse stuff, but rather the complete separation of all material which requires long treatment from the bulk of the sand which can be satisfactorily treated in a much shorter time. But there is one objection to this multiplication of apparatus, namely, that a separate stream of clear water, from the tanks shown above the spitzlutten, has to be supplied to the discharge orifice of each. Otherwise, a portion of the slimy water and fine sand would pass out with the concentrates, which, of course, is undesirable. Now, although this pressure water may not amount to more than 3 or 4 per cent. of the whole battery water for each spitzlutte, yet this means in the aggregate from 18 to 24 per cent. of excess water. This is, of course, not absolutely lost, because in this district some system of returning the battery water is always used. In the cases where the pulp water is immediately clarified and returned to the battery, the excess can also be returned to the classifiers, in which case there is practically no objection to its use for separation purposes. But where the slimes are

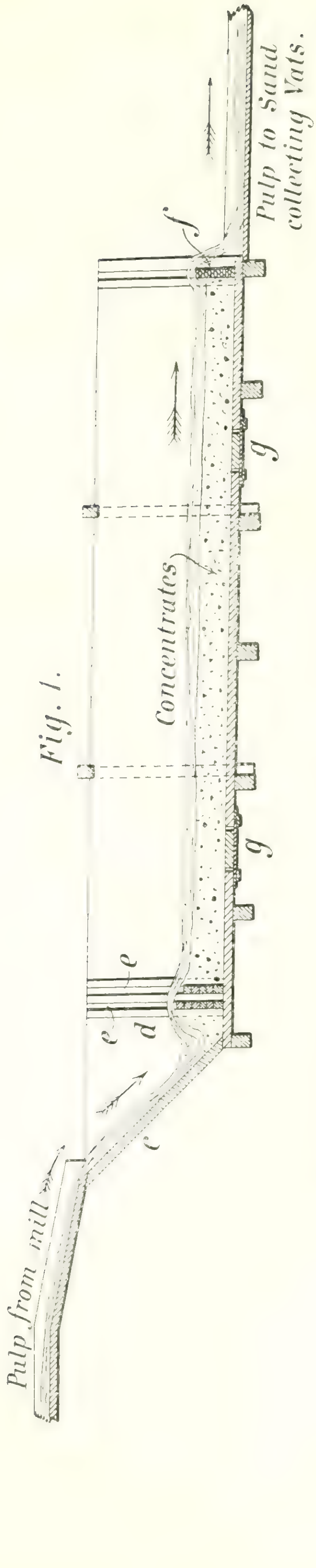


Fig. 1.

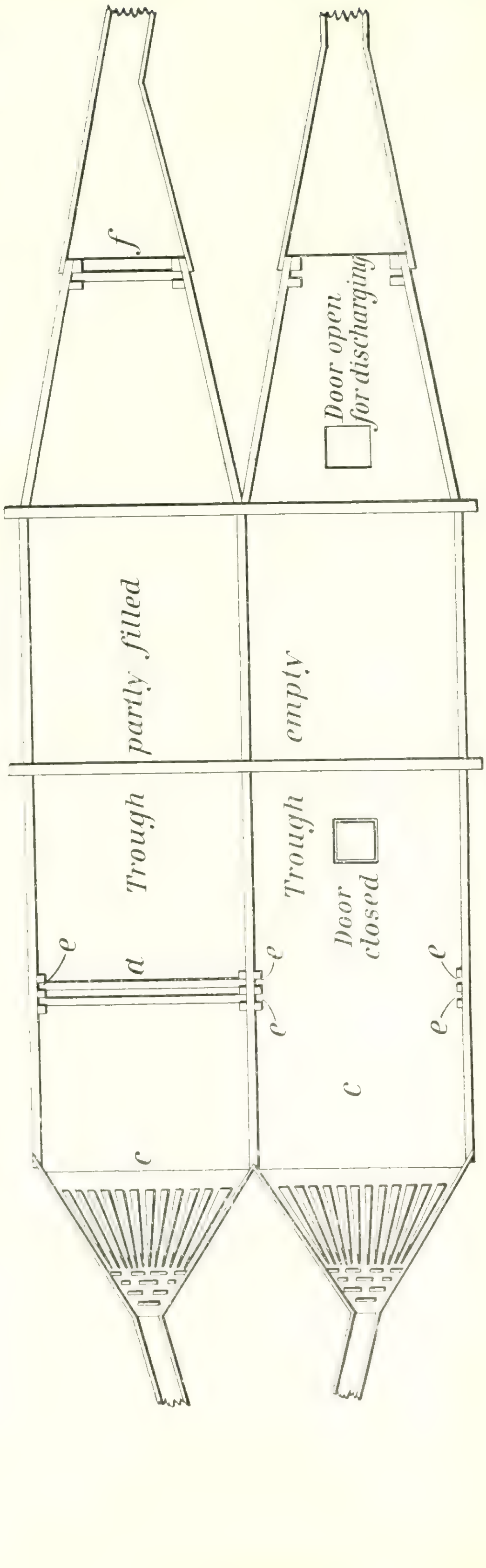


Fig. 2.

TROUGH DESIGNED TO RECEIVE THE PULP FROM EIGHTY STAMPS AT THE MEYER AND CHARLTON MILL.

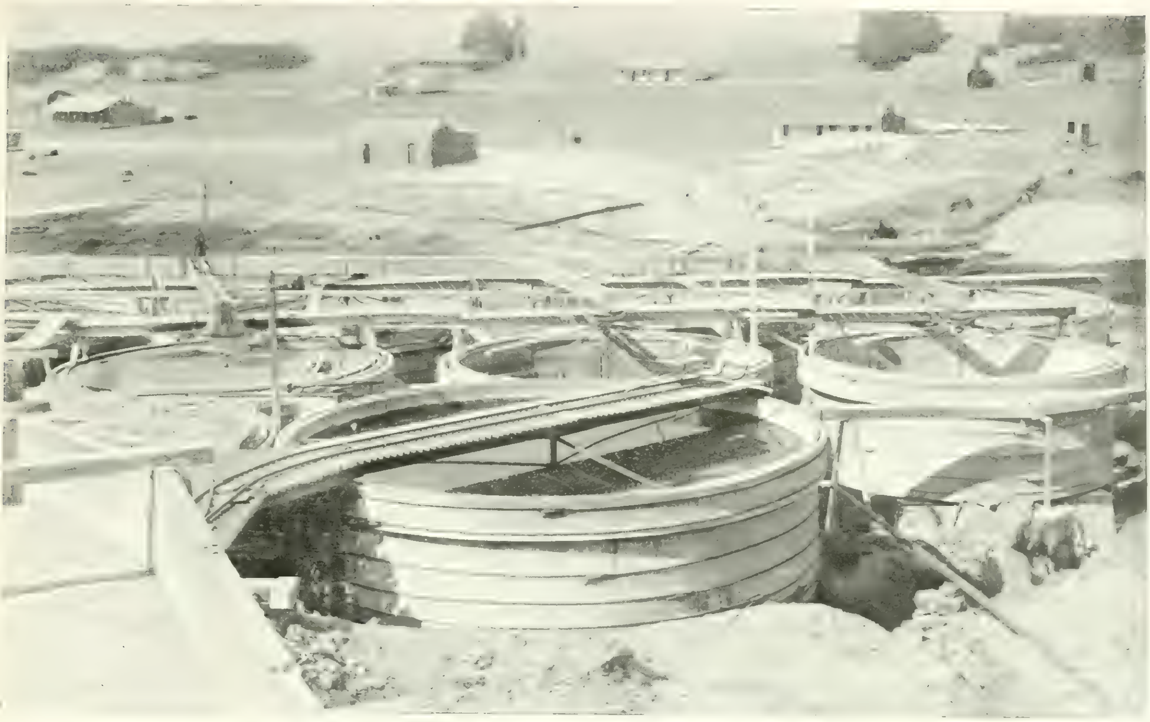


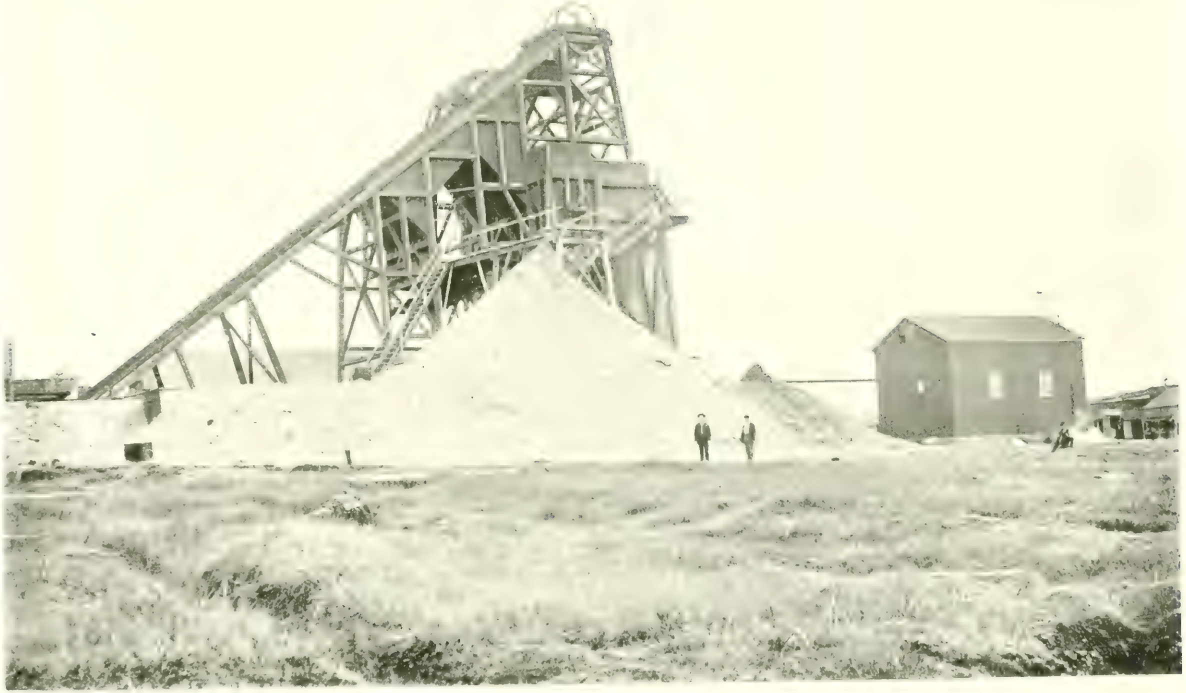
FIG. I. STORAGE VATS FOR ROUGH CONCENTRATES PRODUCED BY SETTLING TROUGHS AT THE MEYER AND CHARLTON MINE. ALSO COLLECTING VATS FOR TAILINGS FLOWING FROM TROUGHS.

too poor for treatment, a large part of the water used finds its way to the main dam, and has to be pumped up again. In cases where the water supply is limited and no means of storage is available, any method which will obviate the necessity for this extra water is of great importance.

CLASSIFICATION WITHOUT PRESSURE WATER.

In dealing with a case of limited water supply, Mr. E. H. Johnson introduced another method of collecting the concentrates in which the pressure water is not required, and which may therefore find important applications in districts subject to droughts. In principle it may be briefly described as the use of the Riltinger trough instead of his pointed box, but there are useful modifications in the Johnson apparatus which deserve a detailed description, and, moreover, the figures given below as to the size of trough used, as well as the grade and value of the concentrate obtained, will be useful when applying the method at other mines for which it may be suitable.

The trough illustrated in fig 2, and in the third and fourth photographs, was designed to receive the pulp from 80 stamps at the Meyer and Charlton mill, crushing about 360 tons per day, which gives a flow of pulp equal to about 75 cubic feet per minute. As the grade of material deposited in the trough depends principally upon the actual velocity of the water, the width of the box is the most important dimension, and for the above-named quantity of pulp a width of 7 ft. is found to give satisfactory results with the ore in question. The length over all is 30 ft., and the depth is 4 ft. 6 in., in order that each trough may hold the concentrates produced from one day's crushing. It is evident that if the pulp from the battery is passed into such an apparatus as shown by the arrows, a certain quantity of



Edward Chester.]

A TYPICAL RAND HEAD GEAR.

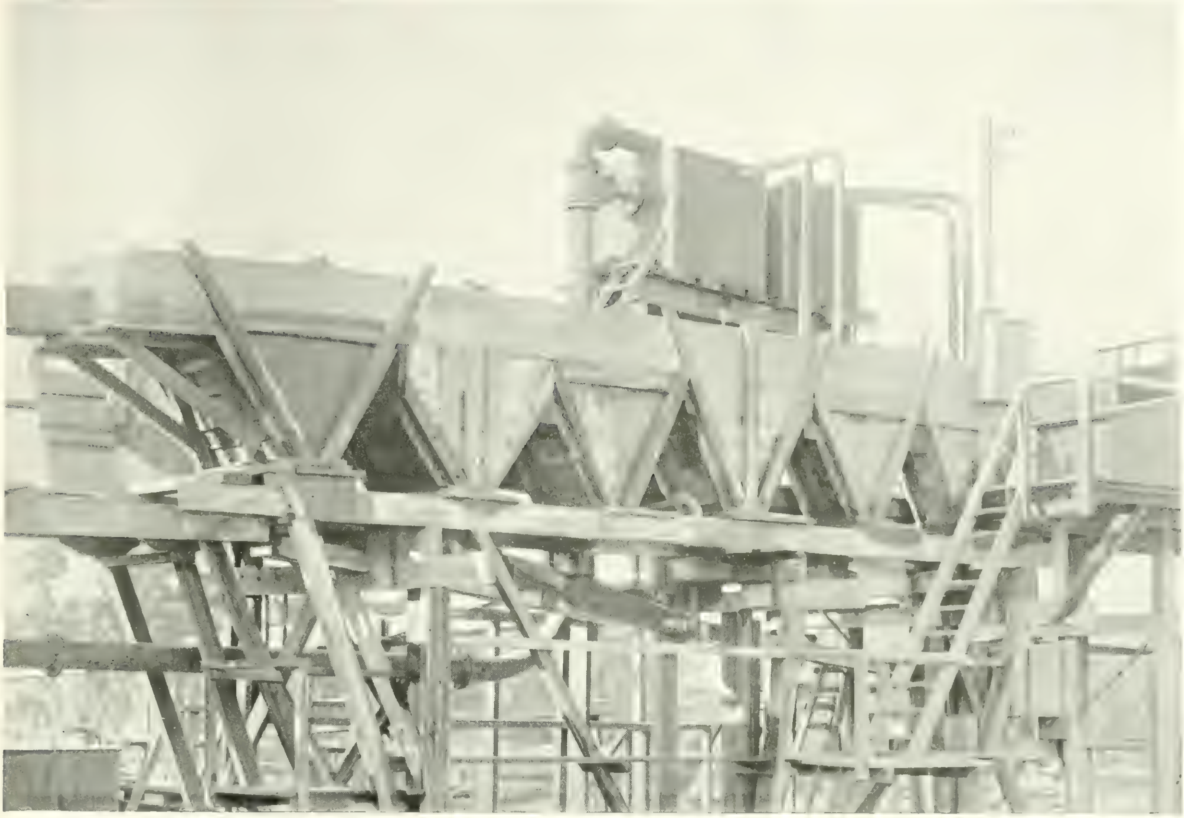


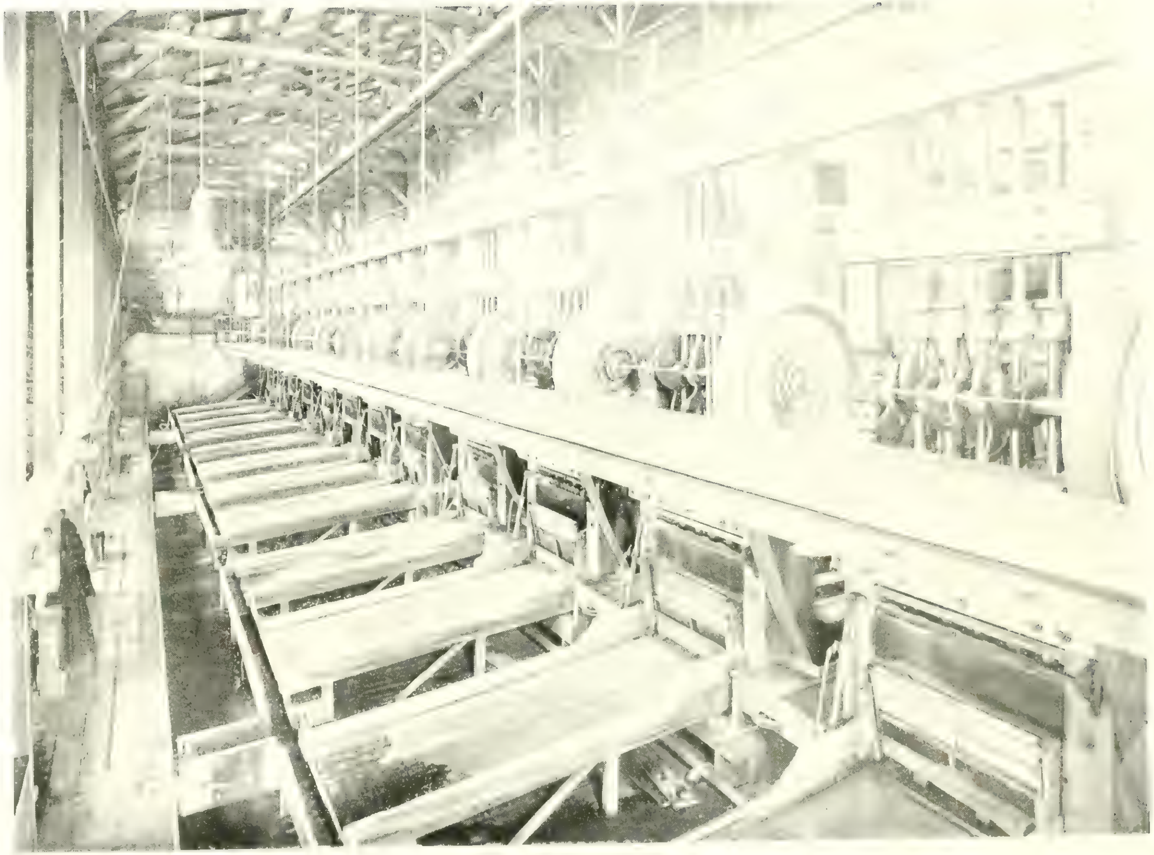
Photo by the Author.]

FIG. 4. GROUP OF SIX SPITZLUTTEN AS USED ON THE WITWATERSRAND FOR ROUGH CONCENTRATION. TANKS FOR PRESSURE ARE SHOWN ABOVE THE SPITZLUTTEN.

material will settle therein, but the rush of water down the steep incline at *c* will, unless neutralised, greatly interfere with this settlement. To prevent this scouring action a double weir is formed at *d* by placing a few strips of wood, 3 in. square in section, across the trough with their ends in the grooves *e, e.* These strips are added from time to time so that this barrier is always a little higher than the collected concentrates. At the out-flow end of the trough a single barrier *f* is formed in a similar manner to retain the concentrates, but in this case the wooden strips are 3 in. by $\frac{1}{2}$ in., so that the level can be raised by very small increments, and the conditions of settlement thereby kept uniform. Two troughs are used in order that the one may be filled while the other is being discharged (through doors in the floor) into trucks beneath. In these trucks the collected concentrate is run along the gridiron truck, seen in the third photo, to the storage vat shown in the centre of the picture. Here it is kept under water to avoid as far as possible the oxidation of the pyrites until a sufficient quantity has accumulated to fill one of the treatment vats, to which it is then transferred.

QUANTITY AND GRADE OF MATERIAL COLLECTED.

The following figures have been worked out from data kindly supplied by Mr. Johnson, and relate to the period of nine months immediately preceding the war. Since that date only part of the mill has been in operation, so no more recent figures can be given because the apparatus cannot again work under the conditions for which it was designed until all the stamps are at work again.



Edward Chester.]

INTERIOR OF 60-STAMP GOLD MILL.

Edward Chester.]

STAMP MILL IN COURSE OF ERECTION.

January to September, 1899.	Tons.	Percentage of tonnage milled.
Total quantity of ore crushed in battery.	84,910	—
Concentrates caught in trough for separate treatment … … …	7,223	8·5
Sands caught afterwards in collecting vats … … … … …	51,540	60·7
Total quantity cyanided …	58,763	69·2

VALUE OF PRODUCTS.

	Total Gold. ozs.	Per ton of each material treated, dwts.	Per ton of ore crushed, dwts.
Concentrates …	6943·275	10·23	1·64
Sands in Vats …	8898·975	3·45	2·10
	15842·25		3·74

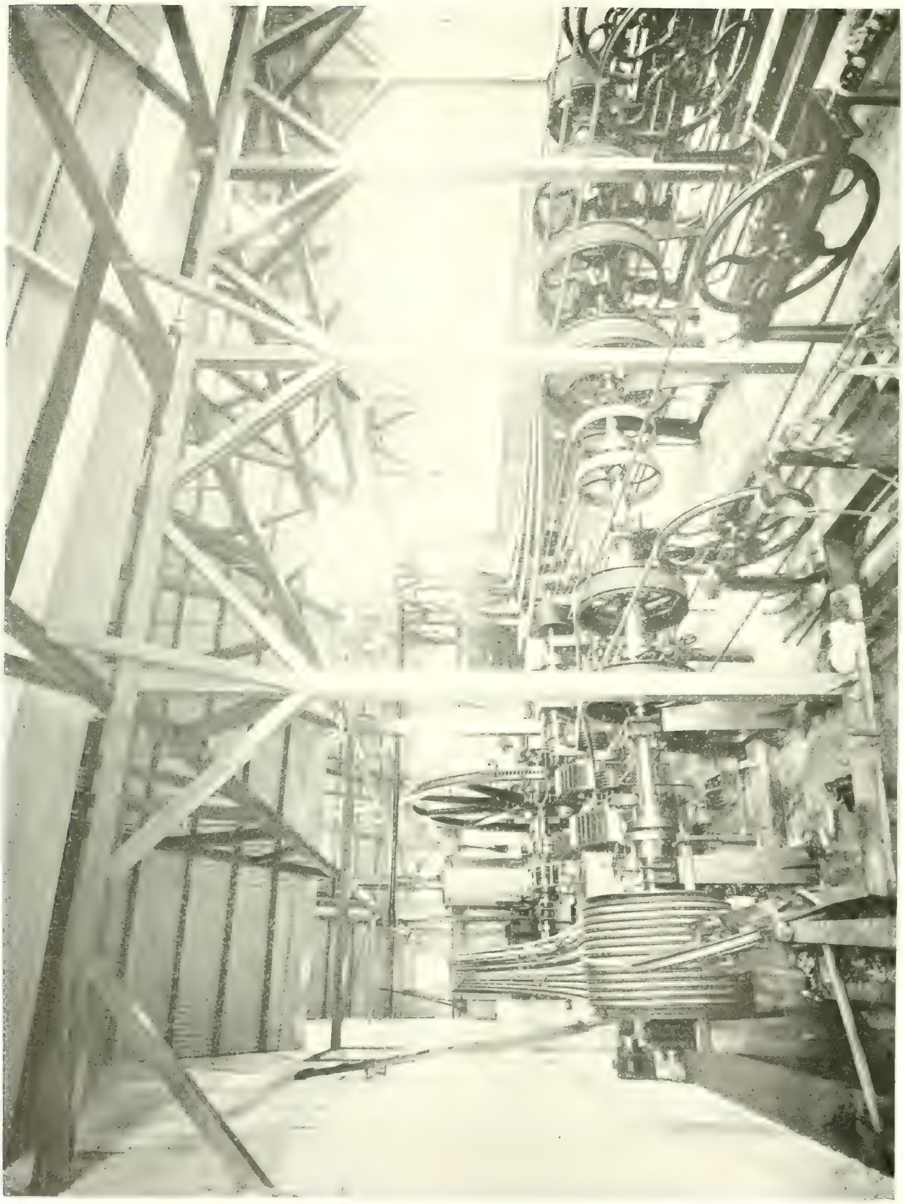
Of the whole gold contained in the material caught for treatment, the concentrates, therefore, carried 43·83 per cent. in only 12·29 per cent. of the total quantity of material, which is an extremely satisfactory result for rough concentration of this class.

The next points to consider are the nature of the product obtained in the trough, and the extraction of the gold from it, as shown by the following lists, carried out by Mr. Johnson.

EXAMINATION OF THE CONCENTRATES.

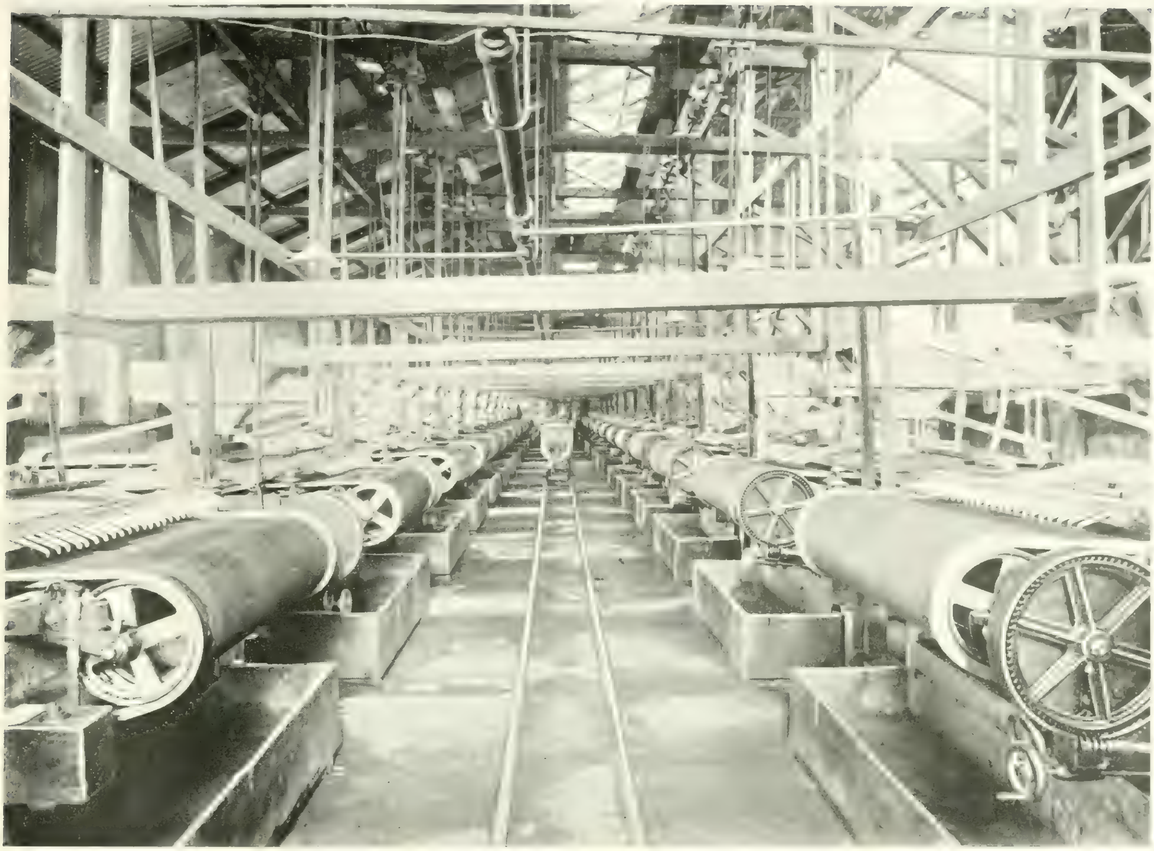
The concentrates were divided by panning into two portions, namely, the pyrites and the sand, and in this way it was found that the collected material contained 20·53 per cent. of clean pyrites. The following table shows the results of the usual sieving tests on each portion and also the residual gold left in each grade after treatment:—

Sieve Mesh.	Percentage of weight.	Dwts. per ton.	Gold in dwts. per ton of total Concentrates.	Percentage of total Gold.
Sands in Concentrates.				
Retained on 30-mesh	10·35	1·6	0·1650	8·75
„ „ 60 „	43·80	1·5	0·6570	[illegible]
„ „ 90 „	16·20	1·6	[illegible]	[illegible]
Passed 90 „	0·12	0·5	[illegible]	[illegible]
Pyrites in Concentrates.				
Retained on 30-mesh	0·26	13·5	[illegible]	[illegible]
„ „ 60 „	7·65	[illegible]	[illegible]	[illegible]
„ „ 90 „	[illegible]	4·2	[illegible]	[illegible]
Passed 90 „	[illegible]	[illegible]	[illegible]	[illegible]
All grades Sand	[illegible]	[illegible]	[illegible]	[illegible]
„ „ Pyrites	[illegible]	[illegible]	[illegible]	[illegible]



Edward Chester.

AN ENGINE ROOM, SHOWING ROPE DRIVES WITH ENDLESS ROPE.



Edward Chester.]

CONCENTRATOR HOUSE, SHOWING VANNERS.

In the foregoing table all the percentages are calculated upon weight and residual value of the whole product, but in the next table the figures are calculated upon weight and value of the clean pyrites alone, so that they may be useful for comparison with results obtained from the treatment of the products of close concentration at other places.

Sieve mesh.	Percentage of weight.	Dwts per ton.	Dwts. per ton of total Pyrites.	Perentage of total gold in Pyrites.
Retained on 30 mesh	1·30	13·5	0·1877	4·54
" 60 "	37·21	4·2	1·5628	37·80
" 90 "	43·72	4·2	1·8362	44·41
Passed 90 "	17·68	3·1	0·5481	13·25
			4·1348	100·00

The importance in practical work of making careful examination of the material both before and after treatment can scarcely be overestimated. For instance, the above tables show at a glance that the extraction of gold increases with the fineness of the grains, and the high assay value of the pyrites retained on the 30 mesh shows how slowly the gold is extracted from coarse grains of mineral. But the tables also show that, with the concentrate in question, the quantity of this coarse mineral is so small as to be relatively unimportant, and that, in considering improvements in gold recovery, the attention of the operator must in this case be directed to the +60 sand and the +60 and +90 pyrites.

WORKSHOP PRACTICE

A RÉSUMÉ OF MACHINE TOOLS, CRANES, AND FOUNDRY MATTERS FOR THE MONTH.

MACHINE TOOLS A NEW CHUCK FOR RAILWAY AXLES.

We illustrate a chuck recently brought out by the Ateliers Demoor, of Brussels, a firm whose speciality lies chiefly in machine tools for railway shops. It does away with the necessity for centring with point centres, and substitutes, what would be termed in America, "collets," or loose jaws, which are self-centring. The general arrangement is shown in fig. 1, in which an axle with a pair of wheels is shown chucked for finishing the treads of the tyres. To the face plates, A A—shown with their toothed driving wheels and the front bearings of the headstocks—the chuck casings, B B, are bolted. They are bored conically to an angle of 22 deg. to receive three loose jaws, C, which are made to grip the journal of the axle by moving the loose headstock longitudinally, causing the tapers of B B to tighten around the loose jaws. To assist the grip of the jaws the faces have V grooves cut in them at an angle of 128 deg.—(Compare with the end view, fig. 2.)

This device has other advantages besides the facility with which chucking is effected without tentative settings of the centres. There is greater rigidity, so that heavy and rapid cuts can be taken without risk of chatter. The parts of the chuck are only four in number, and, being short, they are very rigid. The only movement necessary to fix the work is that of the screw or rack used for actuating the movable head. There is no trouble due to strain on the lathe centres. The wheels being gripped and turned just as they run in their axle boxes, there is no possibility of eccentricity of rotation as there may be in inaccurate setting on centres. And, of course, for truing up wheels after they have been in use some time, this method of gripping by the journals is undoubtedly the best way, in order to true up the threads

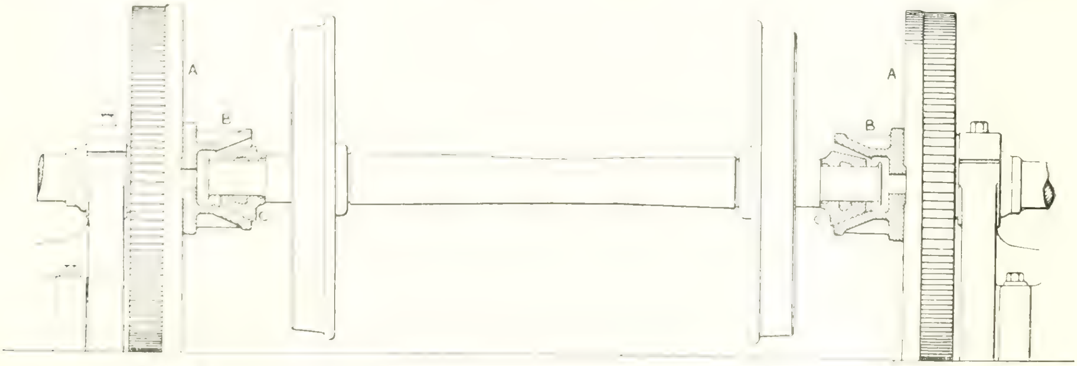


FIG. 1.

and pass over the flats or untrue portions. The manufacturers put it thus: "For a speed of 72 kilometres an hour, and wheels of 1 metre in diameter, an eccentricity of only one millimetre would correspond with a centrifugal effort of 146 kilogrammes for a pair of wheels weighing 900 kilos."

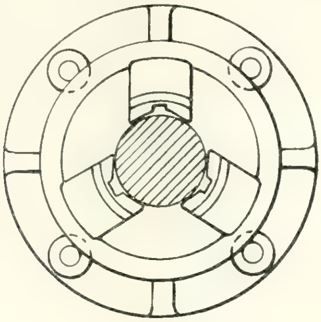


FIG. 2.

The illustration shows a standard type of chuck, which is modified for different conditions, and for different designs of journals. It is not necessary to illustrate all these. One is shown in fig. 3, designed for locomotive wheels having outside crank pins. The difference lies in the body or casing, which is brought out, and recessed from one side to permit the crank pin to clear. Another is seen in fig. 4, designed to avoid the movement

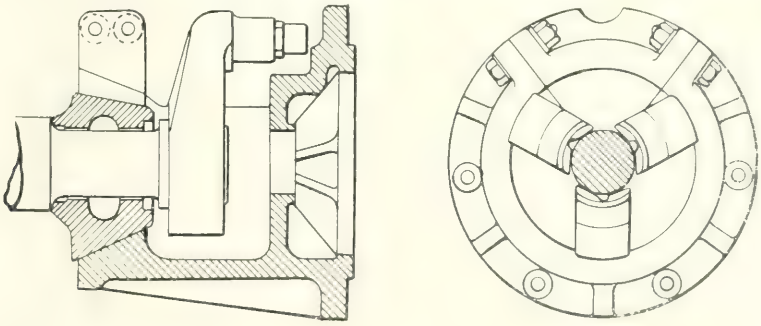


FIG. 3.

of the sliding head. In this the conical seating or body is separate from the flanged portion, sliding within the latter, and being pushed along by sliding the mandrel only of the poppet. Variations in lengths of journals are effected by using different sets of jaws, in the manner shown in figs. 5 and 6.

In connection with this, provision is made for turning the treads of wheels by means of a former. The general arrangement is indicated in fig. 7. There is a recess, A, in one of the slides of the lathe, in which the form piece is inserted. The top slide is controlled by this, being pulled over by a pin, indicated by the small dotted circle, while the tool is traversed by the longitudinal screw by hand or by power through the usual rocking lever. The advantage of having the former concealed in the slides is that it is near the body of the slides, and is at the same time entirely protected from dust and cuttings.

NEW MACHINE TOOLS.

One of the most remarkable signs of the present time is the enormous number of new machine tools which are being brought out month by month, and this in a period of slackening trade. It is only in recent years that new designs have become so commonplace. Manufacturers are ceasing to abide by the old lines, recognising the fact that users of machine tools are eagerly alive to the vast economies which result from the possession of the most economical types. In England, America, and Germany, makers are in earnest rivalry to seize on and embody any and every novelty that makes for efficiency. We might name half a hundred details which are now becoming so familiar that we almost look for them as a matter of course. Cabinet legs, boxed framings, massive construction, provisions for taking up wear, ball thrusts, friction washers, devices for rapid clamping, self-acting movements, dead stops, automatic reversals, increased ranges of speeds and feeds, changes [illegible]

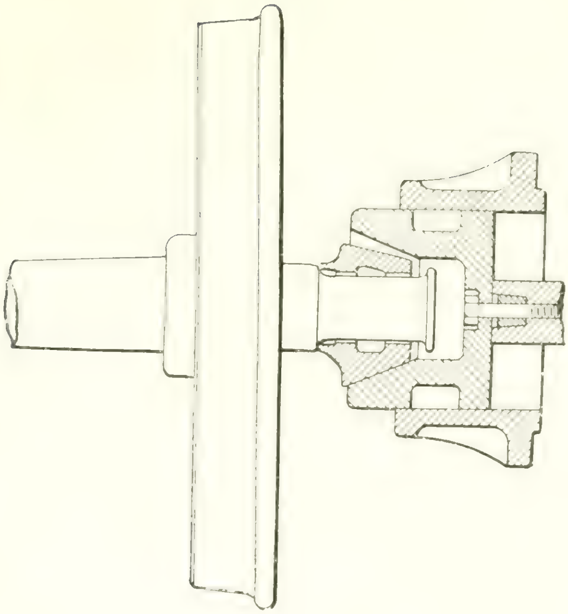


FIG. 4.

during the running of a machine, nests of feed gears, protection to slides and screws, and much else suggest themselves. It is on such details as these that new machines are found to be modified and improved, attention being given to a number of matters, some of which, if taken alone, would appear of small moment, but which in the aggregate go to make the vast difference between a poor and a high-class tool.

A NEW ELECTRICALLY DRIVEN MILLING MACHINE.

We illustrate a recent design of milling machine by the Hendey Machine Company, who are represented in England by Messrs. Charles Neat and Co., of Queen Victoria Street, E.C. The Hendey-Norton box of feed gears is well known, having been very flatteringly and widely imitated since its introduction about ten years ago. It has been applied to other types of machines, as well as lathes, for which it was originally designed. The special feature, however, to which attention is now called, is the motor drive. The motor is placed over the head, where it is carried on a sliding bracket which provides the means by which the belt is slackened and re-tightened when shifting it from one step of the cones to another. This is operated by a cam shaft and lever, the latter being seen under the starting box. The change is effected quickly, and the bracket is securely locked in place.

The driving of the machine is done by spur gears first, seen at the extreme top left hand. These are driven alternatively by two raw hide pinions of different diameters on the armature shaft of the motor. The larger wheels run freely on the shaft, and either one is driven by its pinion through a friction clutch—driving on their interior surfaces like friction pulleys, a device already familiar on the Hendey pillar shapers. Engagement is through the medium of the shipper rod moving through the hollow back gear shaft, and operated by the lever seen in front of the bracket.

BALL RACES FOR CRANES.

The employment of ball races is common enough in machine tools; their application to cranes, however, is not quite so apparent. They are now used to a considerable extent for snatch blocks, to lessen the labour of turning suspended loads about when making settings and adjustments, and are thus taking the place not only of the simple swivels used for the lighter cranes, but also of the races of conical rollers employed in the very heaviest class of cranes.

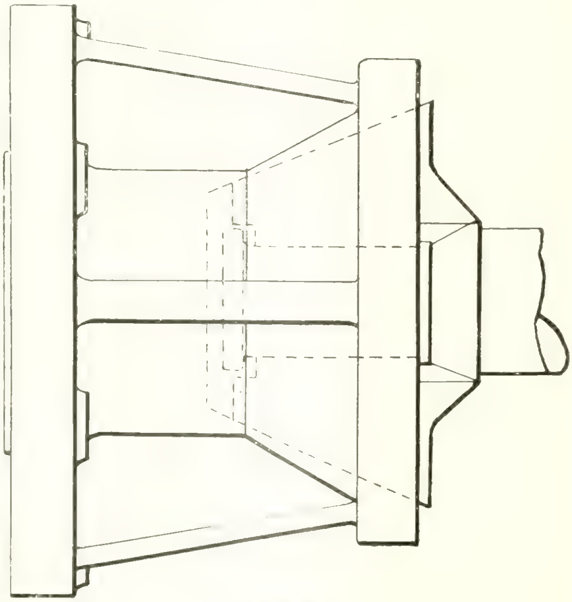
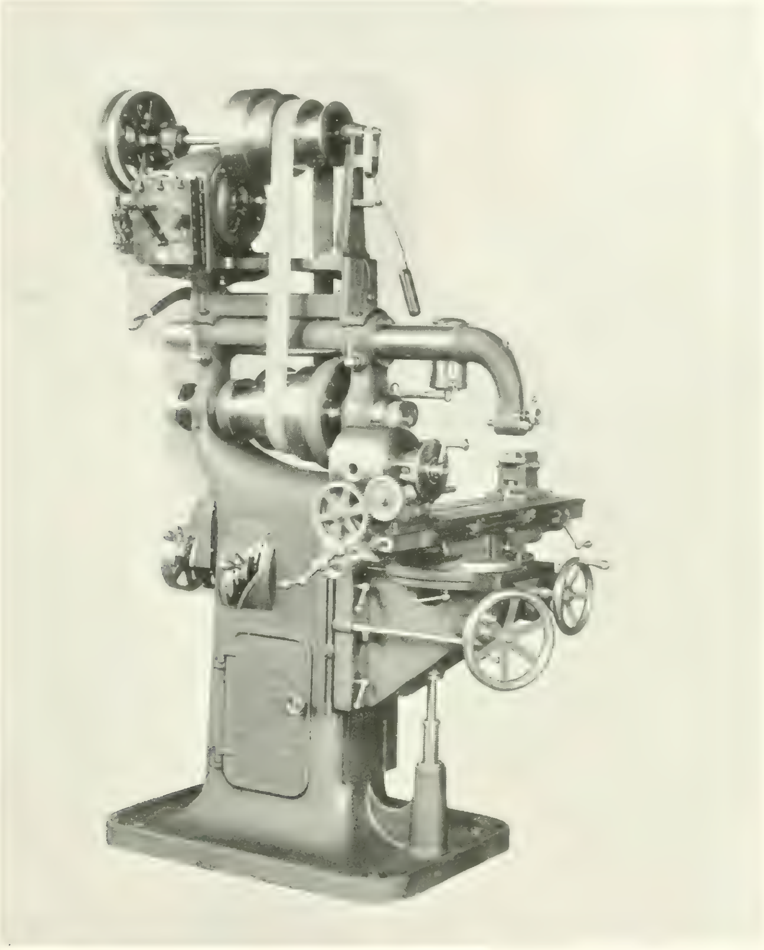


FIG. 5.

The difficulty which has been experienced with conical rollers is connected with hardening and grinding. For these processes no proper provision has existed in the shops of crane makers. Consequently the rollers and their races were turned, and are still, in hard steel, either cast or forged, and left thus, without hardening or grinding. The friction is rather excessive, and early wear results. A good many of this kind have, however, been fitted to heavy cranes. The proper method is to harden and accurately grind them, and for this work the makers of roller bearings are better equipped than any ordinary firms.



ELECTRICALLY DRIVEN MILLING MACHINE. BY THE HENDEY MACHINE COMPANY.

Hardened balls and races are ousting the rollers for snatch blocks, and a large number of good cranes are now fitted with them. Balls are cheaper than the conical rollers, though the latter are still considered more suitable for the heaviest snatch blocks. Sections which ensure a minimum of friction are shown in figs. 8 and 9, by the Auto Machinery Company, Ltd., of Coventry. In fig. 8 the V section is employed, but the angle of slope of the inner and outer faces is different, in order to obviate the slipping and sliding of the balls. The idea is to have, as nearly as practicable, the same velocity ratios in the inner and outer radii of the surfaces in action. In the second design contact of the balls and races occurs only on the top and bottom of concave faces, the radii of which are about twice the radii of the balls

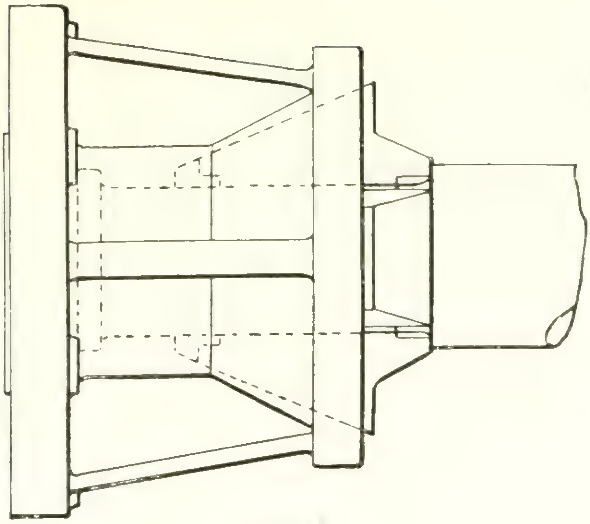


FIG. 6.

These have been employed extensively on hooks and snatch blocks. They are also used at the bottom of crane posts.

A recent special form of ball race, suitable for snatch blocks, is the Hoffmann, made by the Hoffmann Manufacturing Company, Ltd., of Chelmsford. Here the balls run in races, the bottom one of which is sloped and the top one slightly concave. The bearing consists of four parts (fig. 10); the case, A, the floating disc, B, of hardened steel, the cup or collar, C, and the retaining wire. The case should be kept concentric with the neck of the hook. In this instance it is let into a recess in the cross head piece through which the shank of the hook passes. The object of allowing freedom of movement to the floating disc, B, is to permit it to adjust itself automatically to its seat in the casing, so that all the balls shall be loaded equally. The cup or collar, C, fits closely around the neck of the hook, and is capped by a washer which protects the bearing from rain. A very important little detail is the retaining ring wire, *r*. It is sprung into a shallow recess in the casing and retained there by its elasticity. Its object is to prevent the upper disc and the balls from falling out of place, when the bearing is taken out. The entire bearing is thus self-contained, and may be handled as though in one piece. The wire is easily inserted and removed by the fingers. The device is of even greater value in some other applications of this design, as, for instance, to worm gears, lathes, and other horizontal spindles.

FOUNDRY CEMENTS.

It is rather startling to see cements freely advertised for filling up holes in castings and imparting a smooth surface thereto. Old-time moulders, who, when they used beaumontague, had to do so surreptitiously, may be pardoned if they express some astonishment at these advertisements. The writer is old enough to remember the awful Tay Bridge catastrophe, and the damning admissions that were made in

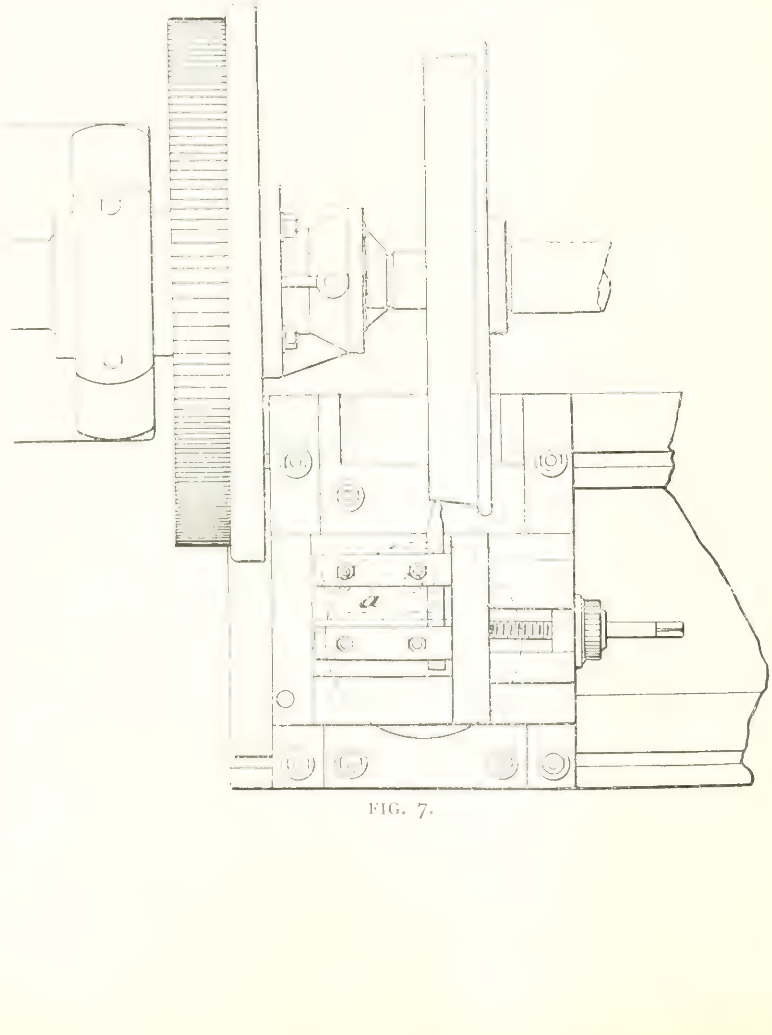


FIG. 7.

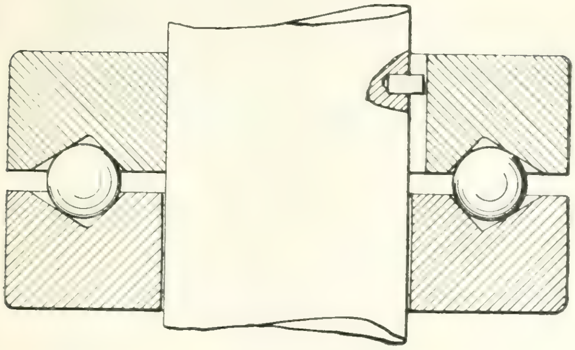


FIG. 8.

court as to the filling up of holes in the faulty columns and the burning on of lugs. No inspector who does his duty will allow a casting to be touched or painted before inspection. It is not for the moulder to say where holes may or may not be filled up, where their presence is risky or otherwise; that is for the inspector to decide. Firms who value their reputations will condemn castings with blow holes to the scrap heap, if they occur in parts where strength is of vital importance, or where tooling has to be done. Some firms will not tolerate such faults at all in any parts, whether vital or not, or they will at least point them out to the inspector for his decision, making no attempt whatever at concealment. Moulders, in such shops, if caught using filling materials would risk their situations. In shops of this class—and, happily, they are numerous—good work with but a small percentage of faulty castings, is regularly turned out. The ideals are high, and the system pursued is made to harmonise with the high standard which is insisted upon. It is bad for the moulders themselves to know that faults in their work can be legitimately concealed.

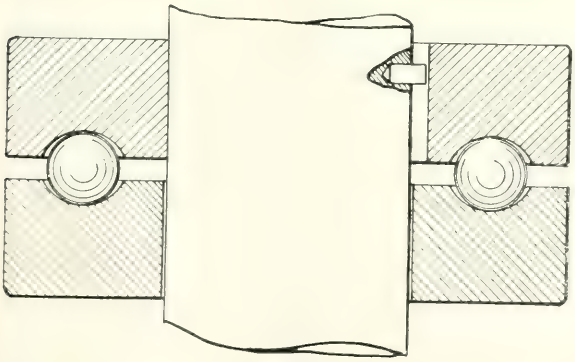


FIG. 9.

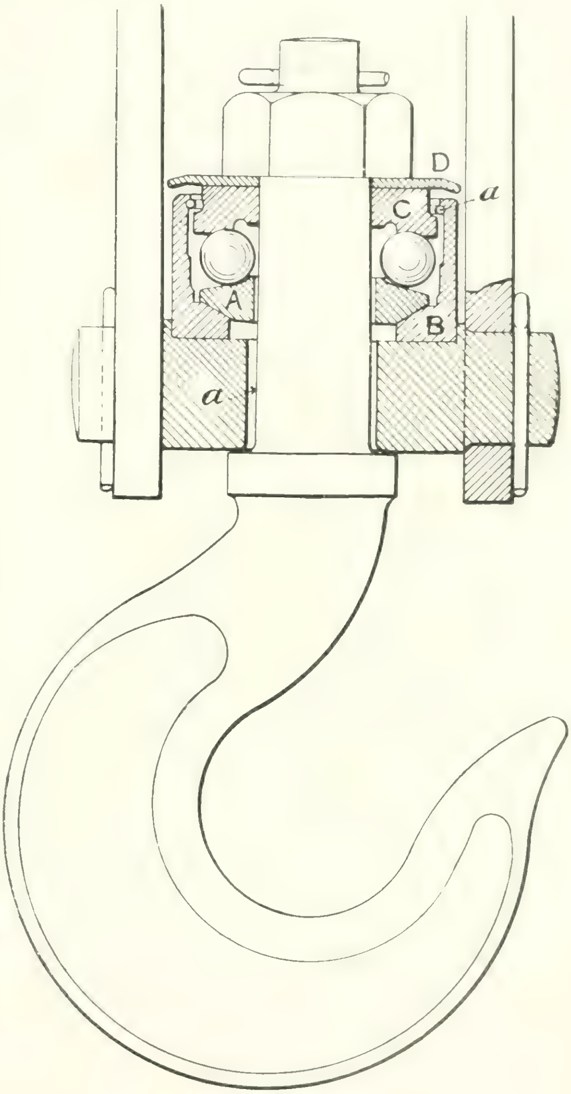
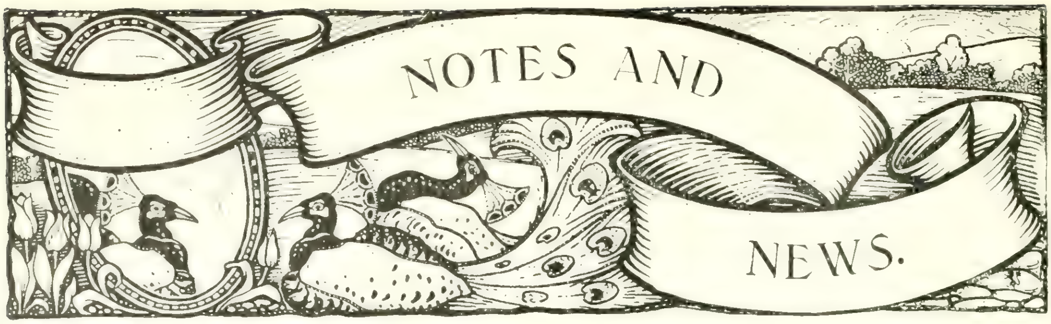


FIG. 10.



New Electrical Pumping Plant.

MESSRS. ERNEST SCOTT AND MOUNTAIN have just completed an important installation of electrical pumping for the Ocean Coal Company for their Treharris machinery Colliery, South Wales. We illustrate a portion of the plant.

The engine is of the horizontal long-stroke compound type, as shown in fig. 1.

Diameter of high-pressure cylinder ...	16¾ inches.
Diameter of low-pressure cylinder ...	26½
Length of stroke	36
Revolutions per minute, approximately ...	100
Steam pressure per square inch	100 lb.

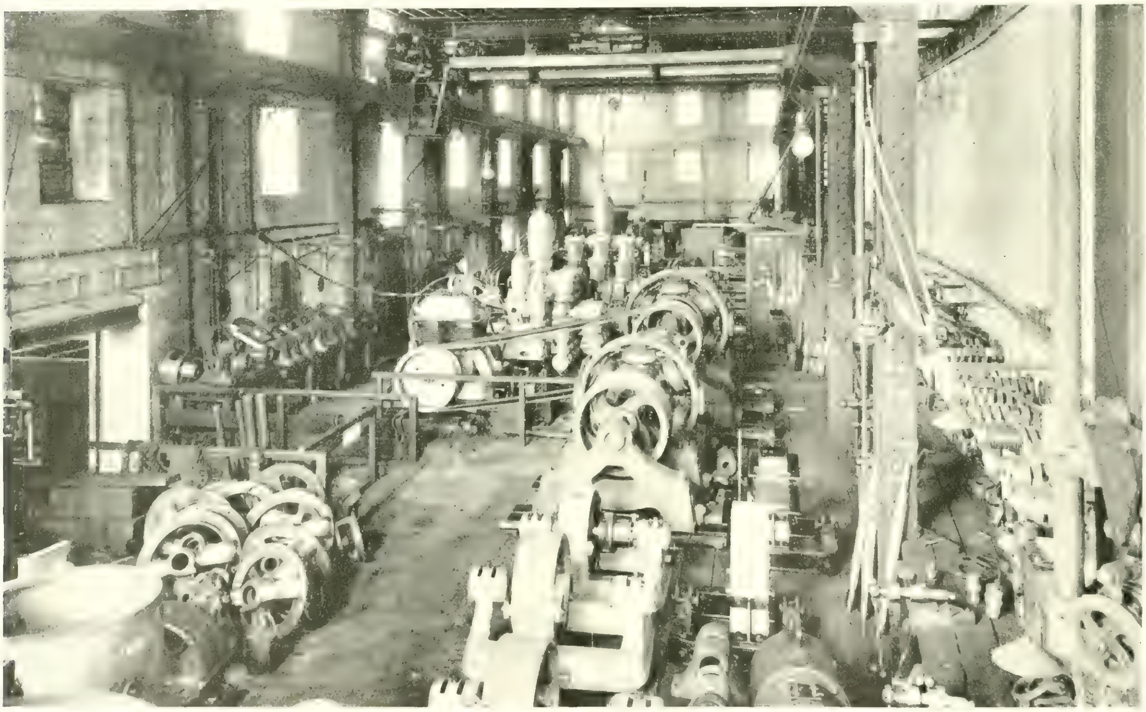
It is fitted with automatic triple-expansion gear to both cylinders, and a heavy rope flywheel 16 ft. in diameter, grooved for fourteen 1½-in. diameter ropes.

The dynamo is of "Scott and Mountain's" six-pole type, as shown in fig. 2, and is constructed to give the following output:—

Total watts...	170,000
Current in amperes	340
Volts at terminals	500
Approximate revolutions per minute ...	400

The dynamo is fitted with three bearings of the self-oiling and self-aligning type, carried on a girder type bedplate, the driving pulley being mounted upon an independent shaft, secured by half coupling to the dynamo spindle.

The brush gear is of the re-action type, carbon block brushes being fitted in specially designed brush-holders, these being supported from a large diameter ring, supported by brackets from the magnets.


PART OF THE NEW ELECTRICAL PUMPING PLANT, DESIGNED FOR TREHARRIS COLLIERY, SOUTH WALES.
MESSRS. ERNEST SCOTT AND MOUNTAIN, LTD.

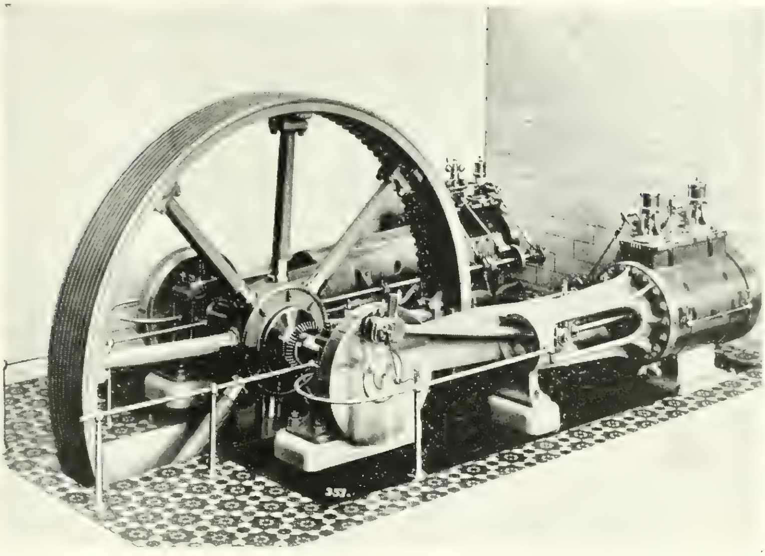


FIG. 1.

The dynamo is mounted upon a cast-iron sliding bedplate, with tightening screws and brackets for taking up the slack of the ropes whilst the machine is running.

The main cables consist of two lengths, each 650 yards, or a total of 1,300 yards, consisting of thirty-seven wires No. 12 S.W.G., insulated with vulcanised bitumen, with a double layer of galvanised iron wires, and then braided and compounded overall. These cables are arranged to carry their own weight in the shaft, and each cable has a sectional area of ·322 square inches.

The main pump is of "Scott and Mountain's" three-throw ram type, all the parts being specially strengthened for the exceptional head against which the pump is to work.

The pump is constructed for the following duty :

Gallons per minute ...	250
Total head in feet	1·500
Diameter of pump rams	9 inches
Length of stroke	18 ,,
Approximate revolutions per minute	21

The pump is fitted with independent and interchangeable pump barrels, suction and delivery branch pipes, suction and delivery valve boxes.

The Labour Market.

A memorandum on the labour market, prepared by the Labour Department of the Board of Trade for the *Labour Gazette*, shows that in coal mining, employment during the four weeks ended November 22nd continued good, and was slightly better than a year ago. At collieries at which 495,647 workpeople were employed, the pits worked on an average 5·51 days per week during the four weeks ended November 22nd, compared with 5·52 days in the four weeks ended October 25th, and 5·33 days per week in the four weeks ended November 23rd, 1901. The number employed at the pits was 1·4 per cent. greater than a year ago.

Iron mining.—Employment continues good. In the 134 mines and open works covered by the returns, employing 15,823 workpeople, the average number of days worked by the mines in the four weeks ended November 22nd was 5·81 per week, as compared with 5·78 in the four weeks ended October 25th and 5·72 a year ago. The number of workpeople employed was 1·0 per cent. greater than a year ago.

Pig iron industry.—Employment showed no change as compared with previous month, and slightly better than a year ago. Returns relating to the works of 114 ironmasters showed that 324 furnaces, employing about 22,300 workpeople, were in blast at the end of November.

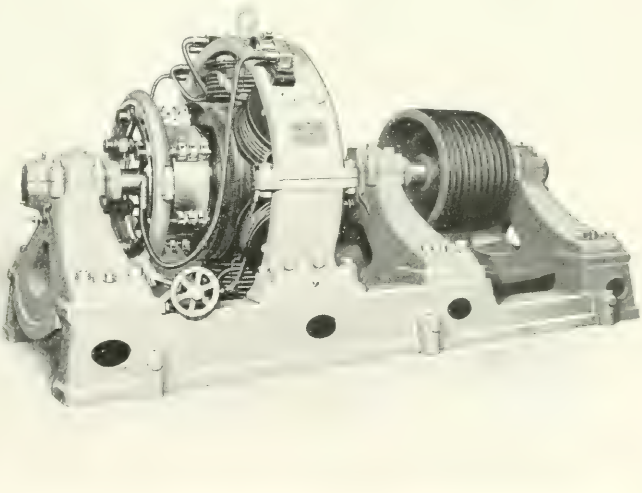
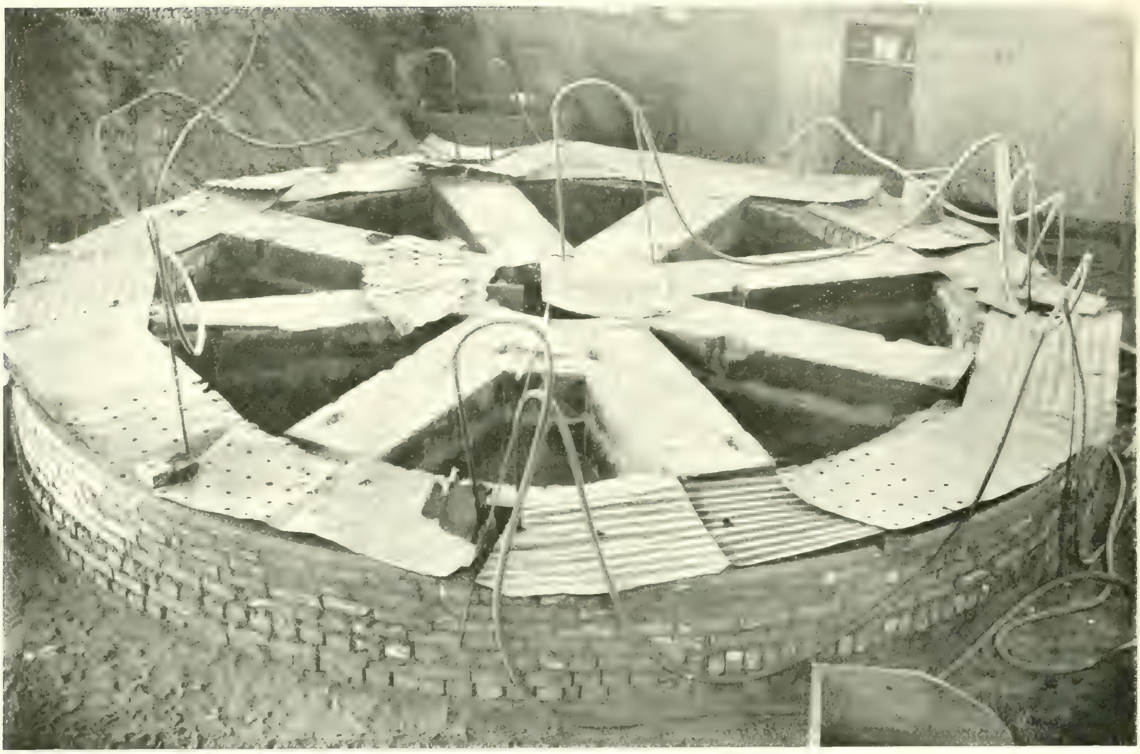


FIG. 2.



DRYING THE MOULD FOR A LARGE FLY-WHEEL BY NATURAL GAS.

compared with the same number at the end of October, and with 321 a year ago.

Iron and steel manufacture.—Employment worse than a month ago, and considerably worse than a year ago. At 201 works covered by the returns, employing 74,500 workpeople in the week ended November 29th, the total volume of employment (taking into account both the number employed and the number of shifts worked) showed a decline of 3 per cent, compared with a month ago, and of 0.5 per cent. as compared with a year ago.

Employment in the engineering and metal trades show no change, on the whole, when compared with October, but it continues worse than a year ago. The percentage of unemployed union members at the end of November was 5, the same percentage as in October, compared with 4·3 per cent. in November, 1901

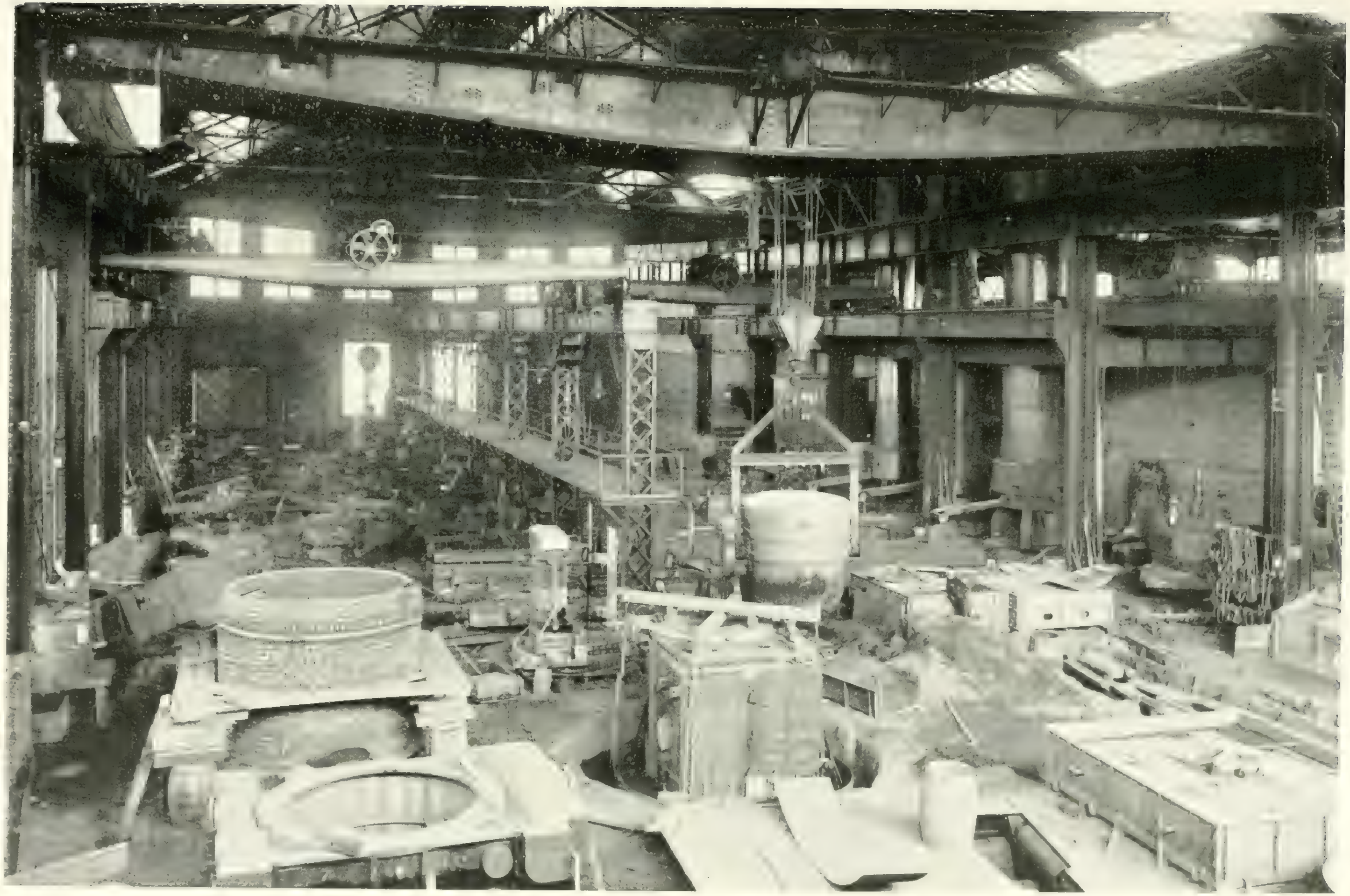
In the shipbuilding trades employment is practically unchanged, and much worse than a year ago. The percentage of unemployed union members at the end of November was 10·7, compared with 10·6 per cent. in October. The percentage for November, 1901, was 4·7.

New Foundry of the William Tod Company, Youngstown, O.

We reproduce an interior view of the new foundry erected by the William Tod Company, at Youngstown, Ohio. During the whole of the work the already existing foundry was kept in operation without the loss of a single day. The main building is 85 ft. wide by 250 ft. long, with a 40 ft. lean-to, in which are located the core department, cupolas, sand bins, wash room, cupola hoist, heating apparatus, air compressors, and general power plant. The core department is served by a 5-ton electric crane having a span of 40 ft., the cores being transferred as they are needed to the main shop by means of a transfer car.

The core ovens, as well as the ovens used for the drying of loam molds and cores, are located outside of the building proper, though easily reached by the cranes. There are two ovens for drying loam moulds, 24 by 10 by 12 ft. high and 24 by 30 by 16 ft. high respectively. The two core ovens are 24 by 12 by 8 ft. high and 16 by 8 by 8 ft. high.

The main part of the foundry is served by two 30-ton cranes of 80-ft. span, commanding the whole of the shop and the runway which extends for 150 feet beyond the building, and covers the yard for cleaning castings, and the space utilised for the storing of loam plates, large flasks, and castings. There are also two 10-ton cranes of 40-ft. span, which command about one-half of the floor space of the foundry. The large cranes are mounted so that they can travel over the 10-ton cranes, and may be used for any especially heavy work in this end of the shop, although the idea is that the 10-ton cranes will ordinarily be able to serve this part of the foundry. The



INTERIOR VIEW, NEW FOUNDRY OF THE WILLIAM TOD COMPANY, YOUNGSTOWN, O.

elevated platform, to be seen on the central row of columns supporting the smaller cranes, is for the use of the operator of the small cranes, which are not furnished with a cab as are the larger cranes. The castings turned out in this end of the foundry are such as do not require the constant operation of the cranes, and, as a general rule, one operator takes care of both.

The greater part of the output of the foundry consists of heavy castings. Many of these are moulded in loam and dry sand, and the method of drying, by natural gas, some of these moulds, which are too large to be handled, as shown in the illustration of a large flywheel, is one that must commend itself for cleanliness and general efficiency. In the mould shown, gas burners are distributed throughout the rim of the wheel as well as one in the hub, all of these being connected with the main supply of this fuel through rubber hose.

Opening of the Nile Dam.

The colossal dam at Assouan was opened with an impressive ceremony by the Khedive on the 10th of December. Among those present were the Duke and Duchess of Connaught, Lord and Lady Cromer, Sir W. E. Garstin, Sir Ernest Cassel, Sir John Aird, the Egyptian Minister of Public Works, and all the leading foreign officials in the Egyptian service.

The Khedive on proceeding to the electric switch to open the sluices of the dam by starting the motors for that purpose, was handed a key in the form of an early Egyptian symbol representing the "Key of the Nile." It is of solid silver, and bears the inscription in English and Arabic, "Opening of the first sluice of the Assouan dam by His Highness the Khedive, in the eleventh year of his reign, Dec. 10, 1902. Presented by Ransome and Rapier, makers of the sluices and lockgates."

The Khedive fitted the key to the starting switch of the motors and turned it, whereupon five sluices were completely opened in seven minutes. The water rushed through with a roar, in great jets, the spray mounting to the top of the dam.

The great dam at Assouan is situated 600 miles above Cairo. It is not, like the Assiout barrage, a solid wall, but is pierced with sluice openings for the flood discharge of the river, which may at certain times amount to 15,000 tons of water per second. There are 180 such openings, mostly 23 ft. high by 6 ft. 6 in. in width, and where these are subject to heavy pressure they are constructed in the well-known Stoney roller pattern.

The total length of the dam is 1¼ miles. The maximum height from the foundation is about 130 ft. The difference of level of water above and below the dam is 67 ft., and the total weight of the masonry is over 1,000,000 tons. Navigation is provided for by a "ladder" of four locks, each of which is 260 ft. long by 32 ft. wide. The masonry is of local granite set in British Portland cement mortar. The interior is of rubble, set by hand, and all the face-work is of coursed rock-faced ashlar.

There was a great pressure at times to get a section completed before the inevitable rise of the Nile, and as much as 3,600 tons of masonry were executed per day, chiefly at one point in the dam. The contract was let to Sir John Aird and Co. in February, 1898, and two months after the signing of the contract the permanent works were commenced, and before the end of the year thousands of natives and hundreds of Italian masons were engaged on the great structure.

Some surprise has been expressed that the speech of Hussein Fakhry Pasha at the inauguration ceremony, while doing full justice to the services of individual Englishmen employed in the construction of the dam, utterley ignored the fact that the work owes its existence entirely to British capital and British enterprise.

It is with the deepest regret that we have to record the death, under exceptionally sad circumstances, of Mr. Albert Walsh, a valued member of the editorial staff of PAGE'S MAGAZINE. Mr. Walsh, a son of Mr. Walter Walsh, author of the "Secret History of the Oxford Movement," was an enthusiastic cyclist, and was returning home from a country ride when he was thrown from his machine in front of a passing tram-car. A kick from one of the horses caused terrible injuries, to which he soon afterwards succumbed at St. Thomas's Hospital. A young journalist of the highest promise, Mr. Walsh endeared himself to every member of the staff, and his untimely death, at the age of 20, has occasioned profound regret, which we share in common with his bereaved family and friends.

Mr. Arthur Wingham.

We are asked to call attention in these columns to the unfortunate position of Mr. Arthur Wingham, Fellow of the Institute of Chemistry, Member of the Society of Chemical Industry, and for many years Fellow of the Chemical Society, with a view to obtaining some pecuniary assistance for his relief.

Mr. Wingham, who is only forty years of age showed great promise as a metallurgist until, in 1890, an attack of paralysis incapacitated him for continuous work. Since that date he has been growing slowly weaker. His sources of income are quite exhausted, owing to his mother, and three brothers (on whom he chiefly depended) having all died within a period of eighteen months.

A committee has been formed for the purpose of collecting a sum sufficient to provide for him, by the purchase of a small annuity, or otherwise; and any subscriptions sent to the treasurer, Mr. Bennett H. Brough, at 28, Victoria Street, London, S.W., or to Mr. D. A. Louis (hon. sec.), at 77, Shirland Gardens, Maida Vale, W., will be gladly received and acknowledged.

Below we append a brief sketch of Mr. Wingham's career:—

Arthur Wingham was born in May, 1862. In 1878 he was admitted as a student in chemistry at the Royal School of Mines, where he was appointed Junior Demonstrator, in 1880, under the late Sir Edward Frankland. From 1882-1886 he was Chemist to the Broughton Copper Company, Manchester, where two or three assistants worked under him. In 1886 he returned to the Royal School of Mines, where he made a series of investigations on English Tobacco. In 1887 to 1888 he carried out, under Sir W. Roberts-Austen, an investigation into Oriental Alloys, and did a considerable amount of other research work. In 1890 he was appointed an Assistant Examiner to the Science and Art Department in Chemistry, and was also engaged as Assayer at the Royal Mint.

The St. Louis Exhibition.

Preparations for the Universal Exhibition, which is to be opened at St. Louis on May 1st, 1904, are going steadily forward, and building operations are well under way. It is the intention of the management that the five principal buildings shall be ready nearly a year before the opening of the gates. Every effort will be made to have each department and building actually ready with its exhibits by May 1, 1904. The floor space of all the buildings for the Exposition proper, and of those erected by the various States, will cover an area of about 200 acres. As most of the structures will be single-storied, these, of themselves, will occupy about one-sixth of the 1,200 acres in the site. In addition, there will be the buildings erected by foreign Governments and by the various societies, and those for the amusement concessions.

Negotiations to obtain the co-operation of foreign countries are going on with all due haste. Those, large and small, which have already accepted, number about twenty-five, and include Great Britain, France, Germany, Italy, Turkey, Japan, China, Korea, Brazil, the Argentine Republic, and some of the other principal countries of South America, Mexico, and one or two of the leading countries of Central America. To this list must also be added Canada, which has set aside 125,000 dols. as a preliminary grant, which, it is thought, will be doubled before the Exhibition opens.

The following table (furnished by a correspondent of *The Times*) illustrates the extent to which Great Britain has participated in former international exhibitions, and gives the amount expended on each since 1867, and also, in square feet, the space occupied. The latter part of the table, in all cases, includes the colonies, while, with regard to that dealing with expenses, it should be mentioned that it has recently been customary for the colonies to defray their own :—

	Paris, 1867.	Philadelphia 1876.	Paris. 1878.	Paris, 1889.	Chicago 1893.	Paris. 1900
Amount expended ...	£ 125,592	£ 50,081	£ 100,083	£ 29,422	£ 60,000	£ 125,000
Space occupied ... Ft.	280,604	194,381	333,618	232,845	517,161	204,012

The Taff Vale Decision.

The trial of the action brought by the Taff Vale Railway Company against the Amalgamated Society of Railway Servants and some of its officials in connection with the strike which occurred on the plaintiffs' railway in August, 1900, was concluded on December 19th last, after having occupied the Court for thirteen days.

The jury found that the defendants conspired to molest and injure the plaintiffs by unlawful means, unlawfully persuaded men whose notices had not expired to break their contracts, and authorised and assisted in carrying out the strike by unlawful means. The question of damages was left to Mr. Justice Wills, the presiding judge, which, with questions of law, will stand over until next term.

Index to Volume I.

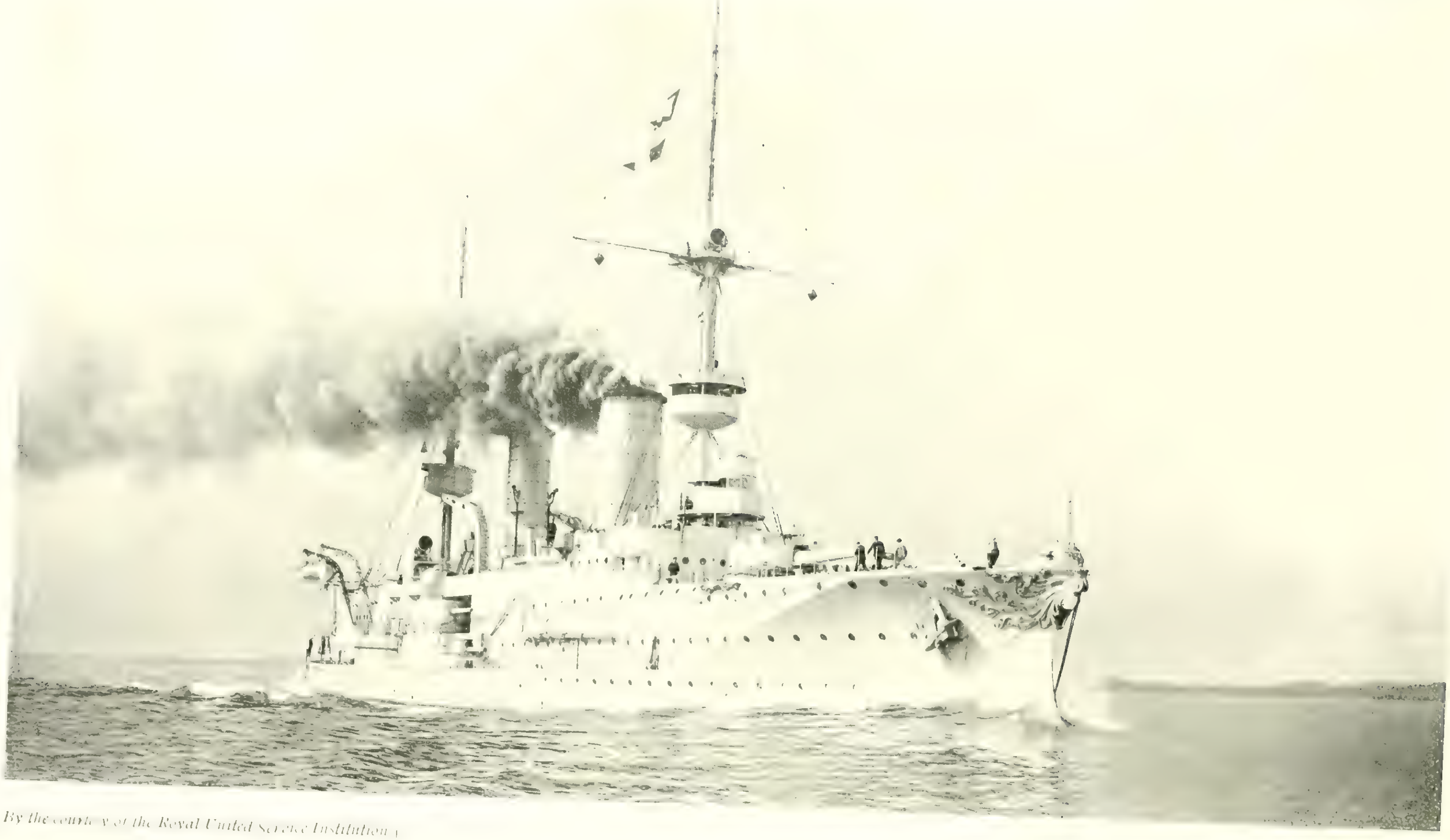
Having received many indications that a comprehensive index to the first volume of PAGE'S MAGAZINE would be acceptable to our readers, we have entrusted the work to a professional indexer, who is sparing no pains to make it as complete and exhaustive as possible.

The compilation has, however, necessitated a considerable expenditure of time, and as, owing to the Christmas holidays we have found it necessary to go to press with the present number somewhat earlier than usual, we have thought it desirable to publish the index to Volume I. with our February number.

Employment in South Africa.

The latest reports from the Transvaal are to the effect that the supply of labour, both at Johannesburg and Pretoria, is more than sufficient, that a great many skilled mechanics and large numbers of unskilled labourers are unable to find work, and that a good deal of distress prevails. Emigrants are warned against going to the Transvaal at the present time, unless they have already secured employment there, or take not less than £100 with them to meet the very high cost of living.

In Cape Colony there is a demand for skilled mechanics, especially those in the building trades, in the inland towns only, and not at Cape Town or the other towns on the coast which are already full of immigrants, but at Kimberley the supply both of miners and mechanics is greater than the demand. The cost of living is very high, and there is no demand whatever for general labourers or incompetent mechanics.



By the courtesy of the Royal United Service Institution.)

THE NEW GERMAN FIRST-CLASS ARMOURED CRUISER "PRINZ HEINRICH," 8,868 TONS; 15,000 I.H.P.; SPEED, 20·5 KNOTS.

ARMOUR PROTECTION: Water-line belt, 4-in. Krupp steel tapering to 3·2 in. at extremities; Redoubt above belt, 165 ft. long, 4 in. to main deck; Main deck casemate battery, 6-in. Krupp steel; Barbettes, hoods, and bulkheads, 6 in.; secondary turrets, 4 in.; Armour deck, 2·8 in. to 2 in.

ARMAMENT: Two 40-cal. 9·4 in., singly in turrets, fore and aft; six 40-cal. 5·0 in. in battery with screens; four similar guns in small turrets; twelve 30-cal. 3·4 in. with shields; ten 1-pounders; all guns quick-firing, and four machine guns. Four torpedo-tubes for 18-in. torpedoes, one submerged in bow, two submerged on broadsides, and one above water in stern.

NAVAL NOTES.

MONTHLY NOTES ON NAVAL PROGRESS IN CONSTRUCTION AND ARMAMENT.

BY

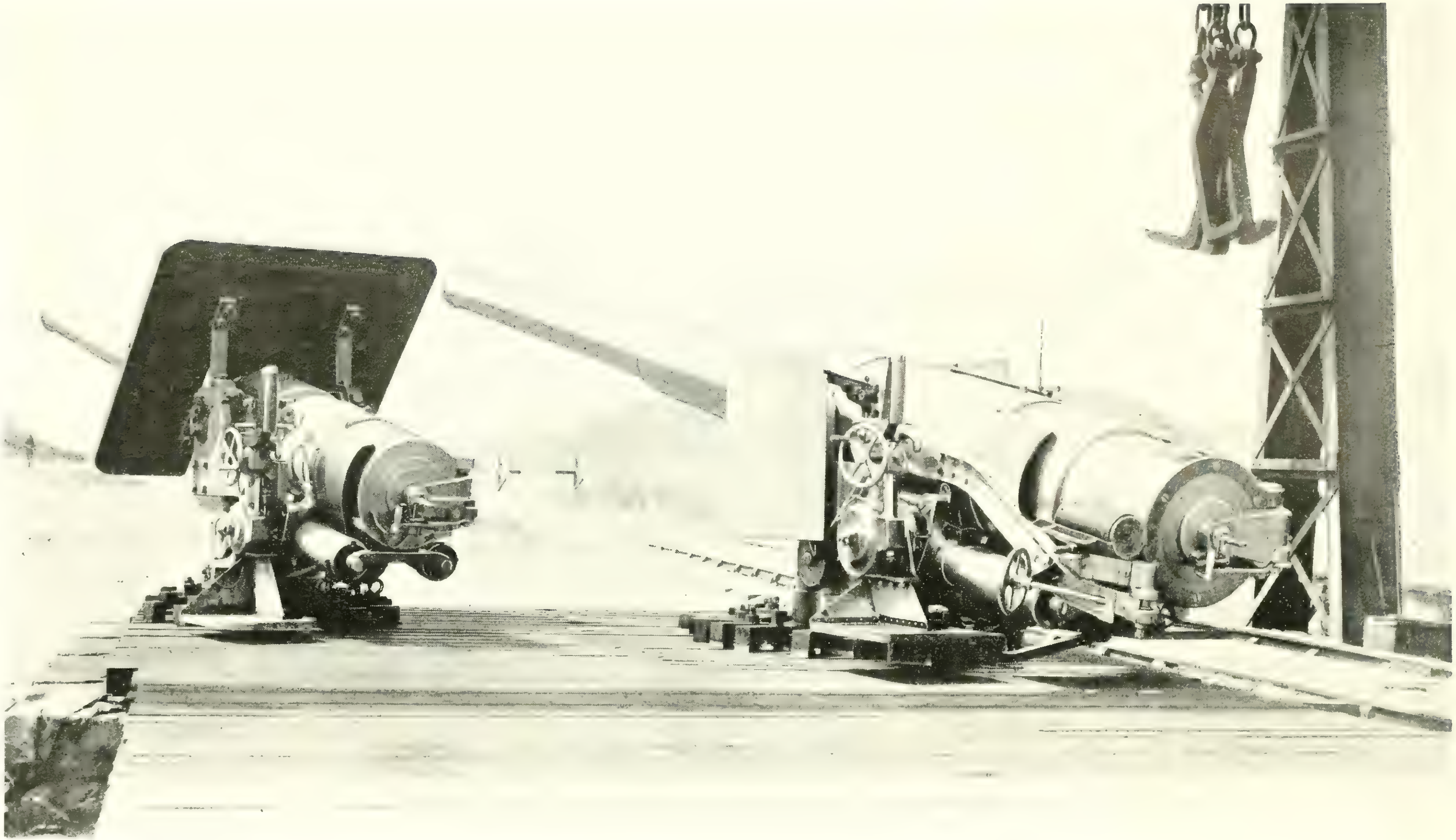
N. I. D.

GREAT BRITAIN.

To my last report of the progress of the battleships building for the Navy there is, at the time of writing, little to add. Of what I have called the older programmes the last vessel of the *Formidable* class, the *Venerable*, has been commissioned, and has proceeded to the Mediterranean. Of the *Duncan* class, three have completed their trials—the *Russell*, *Exmouth*, and *Duncan*. As regards the *Montagu*, it will be remembered that when this vessel commenced her trials these were, so far as the engines were concerned, satisfactory. But Mr. Arnold-Forster explained in the House of Commons that there was a considerable leakage "from the joints of sleeves in the boilers, and a number of lead plugs in the generator tubes blew out, owing to their being incorrectly fitted." The sleeves and plugs, he said, were being replaced, and he anticipated that no further trouble would arise. The "elements" of the boilers were taken out of the ship, and sent back to the works of the contractors at Birkenhead, and it was expected that the necessary repairs would not be completed before some time in January. There remain the *Cornwallis* and *Albemarle*, both of which are completing at Chatham. It was anticipated that the last-named, which was laid down on January 8th, 1900, would be ready for her trials during December, 1902.

The two next battleships are the *Queen* and *Prince of Wales*, building at Devonport and Chatham respectively. Good progress has been made with both of these vessels, which were launched during the past year, in March and May respectively.

The remaining five battleships in hand are the *King Edward VII.*, the *Commonwealth*, *Dominion*, *New Zealand*, and *Hindustan*, which were described in last month's Notes. The keel of the *Hindustan* was laid down in November, and that of the *New Zealand* will, it is expected, be laid down in January, after the launch of the cruiser *Suffolk*. As regards the armoured cruisers, the progress on which has been reported from month to month, interest is specially centred upon the two vessels of 1902-03 programme, one to be built at Pembroke and the other by contract. These vessels are known as the *Duke of Edinburgh* class, and are to be intermediate in size between the *Drake* and *Monmouth* classes. Their displacement will be 13,500 tons, as compared with 14,100 tons of the *Drake* and the 9,800 tons of the *Monmouth*. They will be in length twenty feet shorter than the *Drake* and forty feet longer than the *Monmouth*, but the beam is greater than that of either of these classes. It is, however, in regard to armament that a radical departure has been made, the provision in this direction making these vessels more formidable than any yet laid down. The principal armament of the *Drake* class consists of two 9·2 in. 27-ton guns, but the new vessels will each mount six pieces of this calibre; two



6-IN. AND 7·5-IN. QUICK-FIRING GUNS, MADE AT ELSWICK.

Weight of 6-in. gun, 7 tons 18 cwt. 3 qrs. Do. of mounting, 7 tons 2 cwt. 2 qrs. Muzzle velocity (foot-seconds), 3,100. Weight of projectile, 100 lb. Do. of charge (nitro-cellulose), 41 lb.

Weight of 7·5-in. gun, 15 tons 15 cwt. Do. of mounting, 12 tons 5 cwt. Muzzle velocity (foot-seconds), 2,903. Weight of projectile, 200 lb. Do. of charge (nitro-cellulose), 79 lb.

The breech mechanism of these guns is of the Vickers' "Single Motion" type, *i.e.*, the breech is opened or closed by the single motion of a hand-lever. In this design of breech mechanism the horizontal swing of the hand-lever rotates (locks or unlocks) the breech plug, swings it in or out of the gun, and "cocks" the firing striker. The firing gear is arranged for firing by electricity, or percussion, and is directly operated by the hand-lever, so that the gun is absolutely safe before the breech commences to open. The breech plug is of special design, and is mounted and free to turn on an arm or carrier pivoted at the right-hand side of the breech.

in barbettes, one fore and aft, and four in a central battery on the upper deck. This is a notable increase, although it does not yet place our heavy cruisers in quite the same position as some foreign vessels in this respect. The secondary battery, on the main deck, will contain ten 6-in. quick-firers, five on each side, and all these guns will be under protection. The citadel will extend about three-fifths of the centre part of the ship, with side plating of 6-in. armour. from about five feet below the normal water line up to the main deck, the guns above being behind shields. The belt will be continued forward and abaft the citadel, at the water-line, to the bow and stern, the thickness being from three to four inches, while the armoured-deck will curve down to the bottom of the side platings. The magazines will be placed immediately under the guns, with armoured shoots and coal bunkers above and around them. The smaller armament, mainly mounted on a superstructure, will consist of twenty-eight quick-firing and machine guns.

Of the two ships of the *Cressy* class, which have not yet hoisted the pennant, the *Bacchante*, which has been completed at Chatham, was to have been commissioned in December to join the Cruiser Squadron in the Mediterranean; and the *Euryalus* has been delivered at Devonport. This last-named ship has had a curious experience. Laid down originally at Barrow, she took fire there, while alongside the yard after launching, and was badly injured. She was then sent to Birkenhead to be docked, and while there slipped off the blocks, and again sustained considerable damage. The boilers had to be removed, and part of the keel and frames renewed. She was delivered at the Government yard, having made a satisfactory run round from the contractors on November 18th, the same day on which her sister-ship, the *Hogue*, was commissioned for service in the Channel.

The *Merlin* sloop made a satisfactory trial in the Channel in November, and the third of four torpedo-boats building at the yard of Messrs. Thornycroft was successfully launched, two previous boats, Nos. 109 and 110, having been launched respectively in July and September.

FRANCE.

There are altogether eight battleships building in the French yards. Of these the *Henri IV.*, of 8,948 tons displacement, has been launched, and is practically completed at Cherbourg; the *Suffren*, of 12,728 tons, has been launched. and is nearly completed at Brest. The six remaining are to be all of the same displacement. 14.865 tons. These are the *République*. the launch of which vessel at Brest on September 24th has already been noticed; the others are the *Democratie*, *Patrie*, *Liberté*, *Justice*, and *Verité*. With the exception of the first-named, all of these vessels were to have been built by contract. M. Pelletan. the Minister of Marine, has been sharply criticised for suspending the construction of these vessels. He stated that he has decided not to interfere with the progress of the *Liberté*. which is to be built at Nantes (St. Nazaire), the credits for which ship were in the Budget for 1902. The *Verité* is also to be proceeded with, but on a reduced scale. It is probable, however, that the completion of all these ships will be considerably retarded.

The armoured cruisers in hand are seventeen in number, of which thirteen have been launched. The *Desaix*, *Dupleix*, and *Kléber*, of 7,700 tons, are to be completed in 1903. The *Montcalm*, *Dupetit Thouars*, and *Amiral Gueydon*, of 9,516 tons, should, as regards the first and the last-named, have been completed in 1902, and the third in 1903, but the *Montcalm* alone is in commission. The next class consists of the *Conde*, *Sully*, *Amiral Aube*, *Marseillaise*. and *Gloire*, of 10,014 tons, all of them in the water, and the *Marseillaise* was to have been completed, in 1902, the others in 1903. Then there is the *Jeanne d'Arc*, of 11,270 tons, launched as long ago as 1899, but apparently still incomplete. The largest class of French armoured cruiser comprises five ships—the *Léon Gambetta*, *Victor Hugo*, *Jules Ferry*, *Jules Michelet*, and *Ernest Renan*, of 12.550 tons. The *Léon Gambetta* was launched on October 26th, 1901. Very little has been done to the *Renan* at Brest, and the *Michelet* at L'Orient. The only protected cruisers in hand are *Jurien de la Gravière* and the *Châteaurenault*. These ships were both to have been completed in 1902, but they are still under trial.

There are twenty-six torpedo-boat destroyers in hand, twenty-five torpedo-boats, and twenty-four submarines, all in various stages of construction.

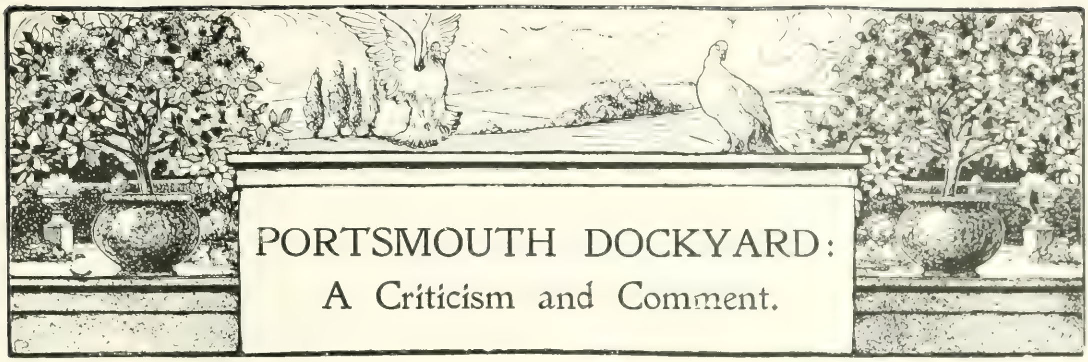
RUSSIA.

The *Kniaz Potemkin Tavritchesky*, which was laid down at the Admiralty Yard, Nicolaieff, on December 27th, 1897, and launched October 9th, 1900, has been placed in commission in the Black Sea. This ship was described in the September issue.

The first-class cruiser *Askold*, mentioned in the November issue, has finished her trials. She made twelve runs, with a draught forward of 22 ft. 2 in. and aft 21 ft. 1 in. The maximum speed attained was 20·1 knots; it will be remembered that at her first trial, and when considerably lighter, she made a speed of 23 knots. This vessel was built at the Germania Yard at Kiel. Two smaller protected cruisers, also mentioned in the November issue, the *Izumrud* and *Jemtchug*, have been laid down at the Admiralty Yard on the Neva. Their dimensions will be: Length, 347 ft. 10 in.; beam, 40 ft.; draught, 16 ft. 3 in.; displacement, 3,100 tons. The engines, of 17,000 i.h.p., will be supplied with steam by sixteen water-tube boilers of the Yarrow type, and the estimated speed is 24 knots. The torpedo-boat destroyer, *Boiki*, mentioned in the October issue as an improvement of the *Sokol*, has completed her trails. This vessel is 210 feet in length, with 21 ft. beam, and a draught of water 6 ft. 2 in. aft and 5 ft. 8 in. forward. Her displacement is 350 tons. She made four runs at forced draught attaining a mean speed of 26 knots, while a four hours' continuous trial at nine-tenths full power gave a mean speed of 23·3 knots. Other ships of this type are to be built. The destroyer *Bravi*, of a similar type but with a slightly larger draught of water, made a mean speed of 26·02 knots in a four-run trial, the speed attained on a four-hours' continuous trial at nine-tenths power gave 22·6 knots.

UNITED STATES.

Although it was stated that no more battleships or cruisers would be asked for by the Secretary of the Navy, the Board of Construction, whose views are supported by the general Board, has presented a report recommending two battleships of 16,000 tons, two armoured cruisers of 14,500 tons, and two gunboats. The view of the Board is that a naval increase should be authorised in each Session of Congress; but a strong opinion exists that it would be worse than useless to go on building unless this construction is accompanied by an increase in the number of officers and enlisted men. It was originally contemplated, in regard to the cruisers, that they should have 25,000 h.p., and a speed of 23 knots, but when greater protection was decided upon, the weight was increased by 200 tons, and it was then proposed to reduce the horse-power to 23,000, with a speed of 22 knots. With regard to the armoured cruisers *Tennessee* and *Washington*, of the previous year's programme, Congress prescribed a maximum displacement of 14,500 tons, with "the highest possible speed." A dispute therefore arose between the advocates of a powerful armament and large protection and those who would have liked a higher speed, and were prepared to sacrifice for it something in the matter of offence and protection. Of the Board, which consisted of five officers, Rear-Admirals Bowles and O'Neil, with Captain Sigsbee, advocated heavy armour and a powerful armament, and these were eventually joined by Rear-Admiral Bradford, leaving Rear-Admiral Melville, the engineer-in-chief of the Navy, in a minority of one. The latter maintains that these vessels will be practically battleships, and not armoured cruisers, and he doubts if even a speed of 22 knots will be obtained. The armament is to comprise four 10-in. guns in barbettes, with 10-in. protection, sixteen 6-in., twenty-two 3-in., twelve 3-pounders, four 1-pounders, and six machine and automatic guns. The armoured decks are to be of a maximum thickness of 4½ in., the bulkheads of 5 in., and the belt armour of 6 in. The two battleships mentioned in the November issue are to be built, the *Louisiana* at Newport News and the *Connecticut* at the New York Navy Yard. The battleship *Pennsylvania* was to be launched in December.



PORTSMOUTH DOCKYARD:
A Criticism and Comment.

BY

"SCIO."

The author of the following article, who has special knowledge of our dockyards, their development, function, and character, deals critically with the article on Portsmouth Dockyard by Mr. W. Price, which appeared in our December issue.—EDITOR.

THE recent article on Portsmouth Dockyard published in this magazine is not likely to pass unchallenged by naval men, for while exhibiting a most laudable desire for engineering efficiency in the dockyards and especially at Portsmouth, Mr. Price has entered upon a somewhat thorny controversy. I venture to challenge his general argument, and in doing so it may be advisable not only to criticise some of the statements made concerning the effectiveness of these great institutions, but also to emphasise the very important bearing they have upon the manufactures of the country.

THE ALLEGED DEFICIENCY.

I must dissent altogether from the statement to the effect that " a royal dockyard is just a big engineering and shipbuilding establishment that is prevented by red tape from becoming as efficient at all points as the best of private yards are." It is, indeed, very much more than that. Leaving the matter of this efficiency aside for the moment, I should like it to be understood that a royal dockyard is a national establishment intended to be, as Portsmouth Dockyard certainly is, the home and base of a fleet, which it is its business to keep, according to national policy, efficient and sufficient, supplying that fleet in every necessary respect. Such a dockyard must be fully equipped with naval, ordnance, and victualling stores. It must be ready, in its docks and basins, to undertake the fitting and repair of ships of all classes. In the case of new ships and ships brought forward from the Reserve, it must possess an organisation and machinery which will enable it to prepare them for commission, and to supply them, through many channels, with everything they require, so that they may go to sea perfectly equipped in all personal and material respects. The final fruit and crown of the work of a dockyard lies in the great share it must have in mobilisation for war, in which, though the constructive department would have much to do, others would transcend it in importance. Indeed, a royal dockyard is not necessarily a shipbuilding establishment ; there are great dockyards, like Gibraltar and Malta, which have not that character at all.

QUALIFICATIONS OF ADMIRAL SUPERINTENDENTS.

These considerations should mitigate the severity of Mr. Price's animadversions upon the strongly naval character of dockyard administration. He appears to consider it a disadvantage that admiral-superintendents are men who have spent the greater part of their lives at sea. Now, I contend, on the other hand, that they are thereby specially fitted for their work, and competent to understand those essential features in all naval preparation, which it is the object of dockyards to achieve. As a matter of fact great private shipbuilding establishments, like those at Elswick and Barrow, have found it necessary or desirable to secure naval men to direct or supervise their work. I have good reason to know that an impression prevails among officers afloat that the actual naval influence in constructive work is not strong enough that there are fittings and arrangements in ships of war that appear excellent when they are introduced, but are not always advantageous in practical work. As to the "big industrial concerns," which the dockyard admirals have to superintend, these officers have their civil assistants, their chief constructors, constructors, chief and superintending engineers, engineering assistants, electricians, store and accounting officers, civil engineers and others to carry on and direct the practical work of the yard. There is certainly no conspicuous shortage in the engineering or business staff, however much there may be at times in individual capacity. This system is undoubtedly good. Establishments, it is true, do not a'ways keep up to high-water mark, but since the state of things that prevailed twenty years ago, the dockyards have made a great advance in efficiency. As a former chief constructor at Portsmouth told a Parliamentary Committee they were put on their mettle and their officers were imbued with the idea that they must show the best results. They gained a freer hand, and were enabled, when contracts had been signed, to enter into direct relations with contractors, which was, and is, most advantageous. Greater rapidity of work resulted, and Portsmouth has built battleships at a cheaper rate than has ever been attained, I believe, by any foreign establishment. Rapid building is usually economical building. The *Royal Sovereign*, built at Portsmouth, was in commission within 32 months of being laid down, and such was the advance that in the case of the *Majestic* the period was abridged to 22 months. This was an excellent result, and though, owing to some untoward circumstances, it has not since been equalled, it shows of what Portsmouth Dockyard is capable.

PRIMARY PURPOSE OF THE DOCKYARDS.

What it seems to me desirable to realise is that the dockyards are not, as I have suggested, primarily intended for building or manufacturing purposes. They are, to a far greater extent, repairing yards. They certainly undertake shipbuilding upon a very large scale, and it may be conceived as eminently desirable that they should be equipped with every modern thing. But here finance rules everything: it is all a question of money, and those who know the history of our dockyards are well aware that within recent years a prodigious amount has been expended upon them. Portsmouth in particular has expanded marvellously, and its new basins and docks are not surpassed in the world. Certainly the Admiralty has in this matter lacked neither courage nor understanding of what it had to do. It is even now introducing new plant to displace things that are obsolescent, and it is very unfair to accuse the Board of remissness in this matter. Not long since several of its members visited Messrs. Vickers's establishment to see with their own eyes what was new in it, but it would be quite Utopian, under the conditions of the British constitution, to expect any government establishment to rival in ready enterprise private establishments like those Mr. Price has in his mind. He makes the unaccountable statement that Portsmouth Dockyard possesses but one building slip—but this is perhaps an accidental error.

A QUESTION OF POLICY.

Mr. Price appears to think that the dockyard should be fitted for the manufacture of engines and boilers, and he implies that the Admiralty officials are compelled in nearly every case to obtain engines from private contractors, knowing well the incapacity of the dockyards. The truth is that the matter is all one of policy. It would, no doubt, be possible, if Parliament voted the supplies to enable Portsmouth Dockyard to build engines and boilers of the largest class. It would even be possible to establish armour-plate factories, ordnance factories, and other works to manufacture the fittings or parts of warships. It has, however, been the wise and consistent policy of the Admiralty to encourage private industry everywhere. The building of a battleship at Portsmouth has a stimulating influence in many industries throughout the country. The yard is in direct railway communication with all the great centres of manufacture, and materials can be brought alongside the very ship into which they are to be built.

I think it is useful to point out, in an engineering magazine, that to change this system would have very unfortunate results. By enlisting the services of private manufacturers in the construction of machinery for dockyard-built ships, the use is secured of the immense plant of the country, with the co-operation of private engineers of the widest experience and the greatest skill. It is sometimes forgotten that not only machinery and boilers, but steering engines, air-compressing machinery, dynamos, evaporators and condensers, pumps, hydraulic machinery, boat hoists, coal and ash hoists, engine-room telegraphs, revolution indicators, and a host of other fittings are obtained by contract. Can it be contended that the system is in any way defective? The same is true in regard to crank shafts, piston rods, connecting rods, cross-heads, crank-bearing frames, cylinder covers, springs, copper plates, small castings, and a great deal of other manufactured material. As many as thirty different firms have taken part in supplying materials and fittings for a single warship, and thus the labour has been distributed throughout the country.

From these considerations the conclusion may be reached that, after all, there may be more important things for the Admiralty to expend its resources upon than the acquisition of the latest machine tool from America. The provision of berthing accommodation and of large coaling facilities has been essential, with the widening of dock entrances, and the enlargement of certain of the docks. Gun mounting stores, electrical shops, and the like have been built, and I believe it would be very difficult to show, with the resources available, that the Admiralty could have done any better. It is certainly untrue to say that the Board are prone to consider dockyard equipment as of secondary importance to the multiplication of ships. If less money had been expended upon such great works as Portland and Dover harbours and the vast extension at Gibraltar, it would no doubt have been possible to do all that Mr. Price demands. What I should like to insist upon is that the defects he points out have not prevented Portsmouth from accomplishing work—as in the building of the *Majestic*—that has never been surpassed elsewhere.

SCHEME OF ADMINISTRATION.

The details of dockyard administration are no doubt somewhat complex, but the system is good. Vast numbers of drawings of structural parts of warships are prepared at the dockyard under the authority of the Director of Naval Construction, and when the whole design has been approved, the dockyard takes up the work, the ship is laid out to her full size in the mould loft, and the making of working drawings begins. Such as concern the armament or fighting quality of the ship are passed by the gunnery or other officers of the port, and the whole of the work is supervised by the Comptroller through the Director of Dockyards. The system of contract is brought into play, and when all is ready, the Admiral-Superintendent and his officers find themselves at the head of a very powerful organisation for work. It is a tribute to that system that out of the apparent chaos of materials the finished ship arises, and that the calculations of weights for displacement are a marvellous approximation to what is intended. It is the custom for the admiral-superintendent, the chief constructive officers of the yard, the naval store officer, the captain of the Fleet Reserve and others, to meet every morning at the superintendent's office, and thus the work is organised and directed with perfect understanding of what is in hand, and what is intended by the Admiralty Board.

CONCLUSIONS.

Let me say in conclusion that it is a pleasure to vindicate in some degree the character of the royal dockyard at Portsmouth. As I have admitted, improvements may doubtless be made, but I have insisted that money is at the root of the question, and have suggested that the Admiralty, with wise judgment, devotes the money at its disposal to the more vital matters of naval preparation. A Board which has done so much to strengthen the Mediterranean and Home Squadrons, which has created a Fleet Reserve, and which has elaborated a scheme to regulate the entry and training of officers of all classes intended to meet the new conditions of the day, cannot be described as retrograde, and certainly Portsmouth Dockyard has [illegible] in its hands.

LOCOMOTIVE ENGINEERING NOTES.

Mr. F. W. Webb's Retirement.

The chief locomotive interest of the past month centres in the retirement of Mr. F. W. Webb from the Chief Mechanical Engineership of the London and North-Western Railway. It is not necessary that we should inquire how it comes about that only three months after the Chairman of the London and North-Western Company had pointedly denied that Mr. Webb's retirement was impending, with the additional assurance that the mere rumour had caused the Board "much pain," the same Board should have to announce that the resignation had become an accomplished fact. That is a matter of purely "domestic" concern, but it is none the less interesting, because highly suggestive, even in its relation to the subject of these articles.

A Regret.

What does concern the railway world in general, and the London and North-Western Railway in particular, is the regrettable fact that Mr. Webb should have retired before many important mechanical developments, which he is understood to have matured, have had an opportunity of coming into practical use. It was stated that he had in hand a complete and comprehensive scheme for the electrification of the London and North-Western Railway, in readiness for the time when it should be deemed expedient to adopt so vast and costly a change, and that a plan had been prepared by him for its application to some of the suburban services of several important Lancashire towns, where tramways compete rather keenly with the railway.

Mr. Webb's Locomotives.

That Mr. Webb will be remembered most vividly in connection with his introduction and maintenance of the compounding principle in his express and goods engines is reasonably certain; but other locomotives designed and built or reconstructed by him also merit both notice and high praise. From the time of his accession to the chief command at Crewe he recognised the fact that British express traffic had grown, and would grow, to such imposing dimensions that a single pair of driving-wheels would no longer be trustworthy as providing adequate adhesion for the purpose of traction. So from the outset his express engines have had two pairs of driving-wheels. These have always been coupled, save in the case of his three-cylinder compounds. Of his standard coupled express type, known as the "Precedent" or "Jumbo" class, which have 6-ft. 6-in. coupled wheels and cylinders 17 in. by 24 in., Mr. Webb built seventy entirely new engines, and he converted ninety-six older locomotives into the same class, while he also transformed ninety small and feeble engines into a new express class, almost exactly resembling the "Precedents," save in having wheels 6 in. smaller. These 266 engines still take their turn at the fastest and most important express work on the line, and proportionately to their size and theoretical power, have given results never surpassed, if equalled. Mr. Webb also rebuilt the sixty 7-ft. 6-in. single wheelers originally constructed by the late Mr. J. Ramsbottom in the years 1859 onward, and as rebuilt they still remain thoroughly efficient and up-to-date engines in all respects, excepting size, and able to render most valuable service alike in running light expresses and in assisting heavier ones.

The London and North-Western Compounds.

As regards the 160 compound express locomotives designed and built by Mr. Webb for the London and North-Western Railway, opinions have always differed widely, and probably will continue to differ. But in practical experience those engines have afforded so many instances of excellent work, that if in other cases they have apparently done less satisfactorily, the cause must be sought elsewhere than in defects on the part of the locomotives themselves. The first one hundred of Mr. Webb's compounds were on his three-cylinder system, of which the earliest came out just twenty years ago. Originally there were two 11½-in. high-pressure cylinders placed outside and one 26-in. low-pressure cylinder placed inside the framing, the steam pressure being 160 lb. per square inch. Soon, however, the high-pressure cylinders were enlarged to 13 in. From first to last, and in every type, Mr. Webb has invariably used a piston stroke of 24 in. Thirty were built in this first batch—rather too many as the event proved, for they had hardly all come out when the increased traffic due to the train accelerations of 1884, mastered them, and compelled larger dimensions to be resorted to. And so a second batch, this time numbering forty, came out with smaller—6 ft.—driving-wheels, and larger cylinders, viz., two 14-in. high-pressure and one 30-in. low-pressure. After the further accelerations of 1888, a larger driving-wheel was deemed desirable, and so a diameter of 7 ft. was adopted in the next twenty that were built, while in the last ten of these the boiler power was increased by the barrel being lengthened—a combustion-chamber being placed midway in its length, and the high-pressure cylinders also had their diameter enlarged to 15 in. Ten subsequent engines, the last of the three-cylinder type, were identical, save in having wheels a foot smaller for working on steep gradients.

Their Good and Bad Points.

While the earliest batch of Webb compounds were not entirely successful, owing to the special circumstances above mentioned, and while very little information is available as to the performances of the final ten, it is indisputable that the remaining sixty of the three-cylinder express compounds, viz., the forty "Dreadnoughts," with 6-ft. wheels, the ten "Teutonics" and ten "Greater Britains," with 7-ft., have a vast amount of really fine locomotive work recorded to their credit. They have proved themselves to possess both high speed capacity and large haulage power. Their weak point consisted in the four driving-wheels not being coupled. This absence of coupling constituted them virtually two semi-independent engines on one frame and supplied by one boiler, and, in spite of theoretical provision against any lack of synchronism in the mutual working, it is certain that this did at times occur. As a consequence the records of their work show an occasional flagging or falling off which it is not easy otherwise to account for. The absence of coupling-rods also involves frequent difficulty in starting, as the impulse has to come from small cylinders, having only the ordinary steam pressure, to a single pair of driving-wheels. Well as these three-cylinder compounds have done, it may be affirmed without hesitation that they would do still better were their driving-wheels coupled.

Advantage and Drawback of Side-Rods.

In the present day, with superior quality of material and improved methods of construction—including the fluted shape, which gives enhanced strength without increased weight—the breaking or bending of side-rods is not an accident which should occur except in very rare circumstances. Therefore the [illegible]ness which formerly attached to the use of coupled wheels for fast service no longer prevails. On the other hand, the gain in power of adhesion weight is self-evidently most [illegible] when two pairs of wheels, each carrying a weight of 15 to 17 or 18 tons, are coupled, as compared with the 18 or 19 tons, which is practically the weight limit for a single pair of drivers, and of which only 25 per cent. at the best, more often only 20 or 15 per cent., can be relied upon as available for tractive purposes.

The Four-Cylinder Compounds.

In 1897 Mr. Webb definitely abandoned his three-cylinder type for express work, and adopted four-cylinders, two high-pressure outside, and two low-pressure inside, all four driving one axle, that of the front pair of 7-ft. driving wheels, this pair being coupled to a trailing pair, while the leading end of the locomotive was placed on a "double-radial truck," in fact a pivotless bogie. The boiler pressure was raised from 175 lb. to 200 lb. per square inch. Forty of these engines, which have 15-in. high-pressure cylinders and 20½-in. low-pressure, were built, and they have since been followed by twenty of similar design, but with larger boilers and water-bottom fireboxes giving increased heating surface. These sixty four-cylinder compounds have done, and are doing, some very fine locomotive work, alike in respect of speed and of haulage, but the rule of the traffic department that every London and North-Western engine must take an assistant engine if the load exceed what is computed as "17 coaches," necessarily prevents the new compounds being seen to their best advantage. Still, the fact that one of them unassisted hauled a train weighing 339 tons behind the tender from Crewe to Willesden, 152½ miles, at an average speed of 52½ miles an hour, up and down hill, without ever exceeding a maximum of 65 miles an hour on falling grades, is a testimony to the efficiency of the type which cannot be gainsaid.

Mr. Webb's Goods Engines.

Although Mr. Webb still builds a normal type of goods engine for fast freight traffic, with inside cylinders 18 in. by 24 in., and six 5-ft. coupled wheels, the great majority of his goods and mineral traffic locomotives for many years past have been compounds, and eight-coupled. A large number of these are on his three-cylinder compound principle, but those recently constructed are of the four-cylinder compound type. They have eight coupled wheels 4 ft. 3 in. in diameter, and haul enormous loads with remarkable ease and certainty. Probably there are no more effective goods locomotives in the Kingdom, and it may be noted that Mr. Webb was practically the first of British chief mechanical engineers to recognise the advantage of eight-coupling for heavy freight duty.

London and North-Western Tank Engines.

But although, as has been seen, Mr. Webb has so largely employed compounding in the case of engines for express and goods traffic, he has virtually excluded it from suburban work. Excepting for sporadic experiments with four different types of tank engines, all on the three-cylinder compound plan—one a rebuilt Metropolitan locomotive of the "Fowler" type, having four 5-ft. 9-in. driving-wheels; two others, variants of Mr. Webb's standard 4-ft. 6-in. and 5-ft. 6-in. wheeled tanks; and one having six 5-ft. drivers, two pairs being coupled—Mr. Webb has adhered to the simple high-pressure method in the case of all his tank engines, whether for suburban traffic, branch-line work, or shunting purposes, for all of which he has provided very effectively.

Other Devices.

Even to give a mere explanatory list of the other devices invented by Mr. Webb in connection either with the locomotives themselves or with the works, the greatest in Britain, which he so long controlled and directed at Crewe, would require a bulky catalogue far in excess of available space. It must suffice to say that Mr. Francis William Webb has stamped his name ineffaceably upon the history of the world's railways, locomotives, rolling-stock, and apparatus. Being human, he has doubtless made his due share of mistakes in his long career, but he has done most valuable service, and his retirement to however well-earned repose is a heavy loss to engineering.

THE INCANDESCENT ELECTRIC LAMP.

BY

Ed. C. DE SEGUNDO, A.M.Inst.C.E.

Shows the principles which should be considered in selecting incandescent electric lamps, and indicates the nature of the economies required to further popularise their use.—Editor.

THE history of all that is involved in the development of the incandescent electric lamp from an interesting scientific toy to its present state of practical utility is, perhaps, one of the most striking and instructive instances of great results often springing from apparently small causes.

It may in truth be said that there is more in the incandescent electric lamp than meets the eye; but how many of us to whom the incandescent electric lamp is now no more than a gas burner used to be, appreciate, or even stop to consider, all that is involved in bringing into existence that apparently simple thing which can now be bought for a shilling or less. Someone has said that a thousand inventions have been needed to bring the incandescent lamp to its present degree of practical efficiency, and indeed this is no exaggeration. Volumes could be filled merely with references to the experiments, failures, inventions of machinery and apparatus which have formed the electric lamp's *gradus ad Parnassum*; but in this eminently practical age we cannot stop to consider the past, we have to take the present as we find it and rush with the crowd. It is, therefore, not the intention of these few lines to lure the reader into a consideration of the history of the development of the electric lamp, fascinating though this would be, but rather to draw the attention of those who use the electric lamp to some of its salient characteristics, and thus bring about a better understanding as to the manner in which it should be treated, particularly with regard to the economies which can be effected by an intelligent selection of the many types now in the market.

The value of the manufacturing lamp business of the United States alone has reached a very high figure, the number of incandescent lamps produced being over 20,000,000 per annum, while the output of the European factories may be estimated at not less than another 10,000,000, bringing up the total to between 30,000,000 and 35,000,000 lamps produced per annum.

Taking the value of each lamp at an average of one shilling, the value of the lamps produced per annum mounts up to between £1,500,000 and £1,750,000, which indicates the importance of the industry which has been called into existence by this invention.

The incandescent lamp is apparently so insignificant a feature in electric lighting when compared with the ponderous dynamos and engines, the monster stacks of boilers and concomitant apparatus, and the elaborate means of transmitting and regulating the electric current generated, that it is difficult to believe that the incandescent lamp is the keynote of the progress in the art of electric lighting, and that it is mainly due to the improvements in the incandescent lamp that the profitable utilisation of the vast system of plant and machinery above referred to has been rendered possible; yet such is undeniably the case. It may be said that the incandescent electric lamp is the very soul of the electric lighting industry, and that this industry has waited for the production of a successful incandescent lamp.

The selling price of good lamps has been reduced from 4s. 6d. to one shilling or under, and the amount of light given by the lamps for a specified amount of electrical energy passed through them has been so largely increased that the old type of lamp would now not be worth using, even though it was supplied free of charge. This at first sight may seem to be an anomalous statement, but it is strictly true, and the principles underlying it are not sufficiently appreciated by the ordinary consumer, to whom the lamp that lasts longest appears to be the cheapest lamp. There was never a greater fallacy, and yet it will be a very long time before the general public will appreciate this fact. It is doubtful even whether the important bearing of efficiency in incandescent lamps upon the cost of lighting and upon the advance of the industry as a whole is sufficiently understood even by the responsible managers of electric generating stations. In order to understand the argument which follows, it is necessary to be acquainted with the manner in which light is produced in an electric lamp. The filament, with which we are all familiar, is designed to oppose a resistance to the passage of the electric current, so proportioned that the amount of heat generated by the current in flowing along or through the filament is sufficient to raise the filament to incandescence. Improvements in the manufacture of the filament and of the lamp generally are directed to a reduction of the heat necessary to bring the filament to the same degree of incandescence, and as the heat effect is directly proportional to the product of the square of the current into the resistance, it follows that if the resistance of the filament and the capacity it has of radiating heat are reduced, the amount of heat, and therefore the current required to bring it to full incandescence, will also be reduced. The degree to which this can be carried without unduly reducing the useful life of the lamp is a question of the highest importance, with which manufacturers are now wrestling. Many years ago, when the writer was connected with one of the large electric supply companies in London, the incandescent lamp was really looked upon more as a user of power than as a producer of light, with the result that for a very long time the eight candle-power lamp, which consumed some forty units of electrical energy in every hour, held the field, and no serious efforts were made to improve upon the amount of light given for the expenditure of electrical energy, the demand for electric light was in advance of the supply, the electric supply company got rid of all the energy they could generate, and, as the lamps lasted fairly well, the consumer was fairly well satisfied as long as the company gave him a continuous supply, and consequently the improvement of the efficiency of the electric lamp was probably the last thing that was thought about. The inevitable consequences of the laws of supply and demand are now gradually making the short-sightedness of such a policy apparent. The consumer errs through ignorance, but the supply company, which continues to treat the incandescent lamp as a power user, instead of a light producer, errs through sheer carelessness or inanition, for the enormous importance of lamp efficiency upon the development and popularisation of electric lighting is now realised by all those who look a little ahead; and, in the United States, the system of payment for supply of electrical energy has of recent years been based upon principles which take into account the light given to the consumer rather than the electrical energy consumed by him.

If a consumer happens to be a thinking man, he will probably argue that the lamp that lasts longest must be the cheapest in the end, as the number of times it will have to be renewed will be the least, and in ordering his lamps he will meet any suggestion of the seller of lamps who may try to explain the difference between high and low efficiency lamps with some such argument as this—"I don't know anything about watts and volts and things of that sort, but I do know when I have to renew my lamps, so give me the lamp that will last longest." And, all other things being equal, he would be right, but all other things are not equal. The ordinary consumer can check the life of his lamps, the cost of renewals, and the amount of his bill, but he cannot easily check the degree to which his lamps are acting as power consumers instead of light producers, and the determination of this lies at the bottom of all progress in the popularisation of the electric light. Up to the present the electric light has been judged by the standard of gas lighting. The two have been considered as parallel cases by the public who, having become educated in the idiosyncrasies of gas lighting, very naturally applied the same reasoning to electric lighting. The gas burners and fixtures were procured by the consumer, hence the consumer buys and renews his electric lamps. The gas burner is replaced only when broken, hence the practice of running electric lamps until the filament gives out. Upon consideration the error in thus paralleling gas practice, as it were, becomes evident. The character of the light produced by the burning of gas depends—for a given burner consuming a given quantity of gas per hour—upon the quality of the gas, the burner itself (as long as it was not fouled or mechanically injured) does not influence the light, and as the deterioration of the steatite is little or nothing, there is no need for the burner to be replaced until it gets broken.

When light is produced by the electric current in an incandescent lamp, however, the case is entirely different. The light is not influenced by the "quality" of the current (since the electric fluid is, as far as our knowledge goes, of only one quality), but by the burner, *i.e.*, the incandescent lamp. Lamps sold as being 16 candle-power, say, very often will show very wide variations both in the actual candle-power emitted and in the consumption of energy per candle-power emitted. Again, of two lamps, each using the same amount of electrical energy, one may yield double the lighting effect of the other. It is hardly possible for the average user of incandescent lamps to form any accurate idea as to the amount of light he is getting for a given consumption of electrical energy. He comes to the conclusion that perhaps the room is not so well lighted as it was at the beginning when the new lamps were put in, and he does not see any difference in his electric light bill, and makes up his mind that this is the price that must be paid for the luxury of having a new form of light which offers certain advantages compared with the old form of gas lighting, but he is quite sure that lighting his house by the electric light must cost him many times as much as it did when he had gas. It is quite possible that, in substance, his conclusion is a correct one, and that, light for light, the electric light is costing him a great deal more than gas did, but this is due to an entirely wrong understanding of the function of the electric lamp, whereby the lamp is not used as it should be, and consequently yields a comparatively poor result.

It may be taken as a fundamental principle that the supply and renewal of incandescent lamps by the consumer will always be, as it always has been, the greatest obstacle in the popularisation of the electric light.

It is impossible to expect the average consumer to believe that a lamp which lasts only half as long as another may be far more economical and efficient in spite of the doubled cost of renewals, yet this is a fact and is rendered possible because, at the present low price of lamps, the cost of the electrical energy used during its life is many times that of the lamp itself, and hence if a lamp gives out a given quantity of light with, say, 30 per cent. less consumption of energy as compared with another lamp, the economical lamp will save its first cost more than once, although its life may be shorter than that of the other lamp. To take a concrete example; a 16 c.p. lamp taking 60 watts will have a useful life of 1,000 hours before the candle-power drops 20 per cent., whereas a 16 c.p. lamp taking 50 watts may be given a useful life of 600 hours with the same drop in candle-power. At 6d. per Board of Trade unit the first lamp would consume $\frac{1,000 \times 60}{1,000} \times 6d. = 30s.$ worth of current, and including the price of the lamp would cost 31s. The second lamp would consume in the same period $\frac{1,000 \times 50}{1,000} \times 6d. = 25s.$ worth of electricity, to which must be added $\frac{1,000 \text{ hours}}{600 \text{ hours}} \times 1s.$, or 1s. 8d. for renewals, making a total of 26s. 8d., and showing a saving of 4s. 4d. per lamp installed. In a house having, say, 200 lamps installed, the saving effected might easily reach £15 per annum. This is a matter of considerable moment to the consumer.

For many years lamps were selected according to the amount of energy they consumed only, and the candle-power was allowed to run [illegible] very wide limits. The only testing instrument then available being the watt meter, the low candle-power was allowed to go unnoticed. With the introduction of the photometer, however, into the lamp manufactory, all this has changed, and lamps are now turned out with great exactness as to candle-power and wattage.

The leading electric supply companies in America are now undertaking the supply and renewal of lamps as an inherent part of their system of electric supply. This principle has much to recommend it. The consumer pays so much per lamp installed per annum, for which the supply company undertake to keep him in *light*. It is for the supply company to determine when and how often his lamps shall be renewed ; and as it is manifest that a customer will be better pleased with a good light than with a bad, and as it is equally evident that it is to the interest of the supply company to use lamps which give the most light for a given consumption of electric energy, this system of free renewals puts a premium upon the efficiency of lamps and tends to the popularisation of the electric light. It reacts also very favourably upon the conditions under which lamps are manufactured.

With the supply and renewal of lamps in the control of the company, the manufacturer receives orders for advance delivery. He is therefore able to calculate with some degree of accuracy how many lamps he will be called upon to supply during the year. This enables him to work more steadily, and consequently to devote the necessary time to the many operations involved in turning out lamps of uniform quality, candle-power, and life. The cost of manufacture is lowered while the quality is raised, and these two items are, perhaps, the most potent factors in the popularisation of the electric light.

It is difficult to foresee to what degree of efficiency the electric incandescent lamp may eventually be brought, and to what extent the cost of domestic lighting by electricity may thus be lowered in comparison with the cost of lighting by other methods ; but even without further improvements a great deal could be done towards popularising the electric light if the supply and renewal of incandescent lamps were taken in hand by those in whose power it is to deal intelligently with the matter, and to exercise the necessary control as to the manner in which the lamps are used, so as to ensure a more uniform light to the user, and a reduction in the amount of electrical energy generated at the supply companies' works per lamp connected.

THE TRAINING OF PROFESSIONAL ENGINEERS.

Some further expressions of opinion as to the order of training that can be most advantageously followed by engineering students. Additional comments will be published in the February issue.—EDITOR.

SUPPLEMENTING the practical article contributed to the last number of "PAGE'S MAGAZINE," by Professor John Goodman, M.Inst.C.E., on the Training of Professional Engineers, the following expressions of opinion from other well-known authorities should prove useful to those who are entering upon an engineering career.

Professor A. W. Brightmore, D.Sc., M.Inst. C.E., of the Royal Indian Engineering College, Cooper's Hill, Staines, writes :—

TRAINING OF ENGINEERS.

In the training of engineers the writer considers that more distinction should be drawn between the cases of those preparing to follow the profession of a civil engineer and that of a mechanical engineer, using the former word in its more restricted sense ; because now that specialisation has so much developed, it is only in very exceptional cases that one individual can efficiently cover the whole range of engineering.

The work of the civil engineer, in the above sense, consists in the application of scientific principles to the designs of public works to suit conditions which are never the same in two cases. His connection with machinery is rather concerned with the results obtained by it, its durability and efficient working than its manufacture.

The study of these scientific principles, the requirement of manipulative skill in the employment of survey instruments, the testing of materials of construction, and of the efficiencies of such machines as prime movers and pumps, can be effectively undertaken in the college lecture rooms and laboratories. But when it comes to the construction of such works and the use of materials suitable to each particular structure and district in which it is to be made, practical experience, which can only be gained by residence on works during construction, is absolutely essential.

There appears to the writer no reason why such practical experience should not be gained after the scientific course at college. Such practical course should include some months spent at a bridge-building yard or similar workshop in order that the student may see in what directions money may be saved in designing such structures, without detriment to them, by bearing in mind a number of apparently trivial considerations which might be otherwise overlooked.

Now, the work of the manufacturing engineer consists very largely in the manufacture of machinery which is similar to, or a modification of, what has been made before. In his case an intimate knowledge of existing machinery is essential, and the question of cost enters from the outset into his designs. For a machine to sell at a profit it must not only be scientifically efficient, but, at least, not more costly than similar machines by other makers. To obtain a knowledge of the considerations which lead to economical construction is, in the writer's opinion, impossible in a college workshop. It is quite impracticable to reproduce there the conditions which exist only in actual commercial work. The most that can be hoped for in the time available at college is to teach him how to manipulate hand tools and the *use* of machine tools ; anything more than this would result in employing time, which should have been used in scientific instruction, in making an indifferent workman. He, therefore, considers that the best training for a mechanical engineer is to take a college course and a works course as nearly concurrently as possible. For this purpose, a division of the year into two parts, of which the college and works course each occupy half, appeals to him as the most efficient method of dividing the time.

Professor J. D. Cormack, B.Sc. (University College, London), writes :—

I have read Professor Goodman's article with interest, as it deals with, what appears to me, a most important and difficult question, deserving serious consideration. At the present moment there is no standard course of work or office and college training. If one must precede the other, I prefer the college training first. In exceptional cases, when a lad is well trained in mathematics and pure science, he might, and probably ought to go, to the works or office first ; he is sufficiently well prepared to read and quickly assimilate the technical works which he ought to study during his work or office training. For this reason, also, if a compromise of the nature suggested by Professor Goodman is possible, I prefer the student to go to college first, then to the works or office, and finally complete his college course. If a lad enters the works first, he must continue his studies either on his own account, without supervision, or by taking evening classes, when he is mentally and physically tired. If he neglects study—and few lads have sufficient determination and stamina to work both day and night, even if it were desirable that they should—he is unable to understand the why and wherefore of what he sees, and loses many of his best opportunities. When he enters college he has probably forgotten much of what he learned at school, and, what is worse, he has perhaps forgotten how to study. On the other hand, if he enters college first, and studies theory before practice, he loses much of extreme value in being unable to apply theory to examples of which he has actual experience. His ideas are abstract, and he cannot associate them well with things concrete, though laboratory and workshop practice is, in this respect, of great assistance. And when he leaves college and enters the works, it is at an age at which he is less inclined to undergo, what he might consider the "drudgery" of the works.

I believe in what might be called the "sandwich" system. The college and workshop training should proceed as nearly concurrently as possible; work in the day and study at night is too much for the average boy; the slices of the sandwich are too thin. But six months in the shop or office, and six months in the college, would give time to permit good work to be done in both, and each would be a recreation to the other. There would be no discontinuity, such as there is if three years of one precedes the other; theory and practice would be woven into one well-connected scheme. Five years of such a system would be quite sufficient training. The first year might be spent entirely at college, chiefly studying pure science and mathematics; in the second year six months might be devoted to science and technical training, and six months to the works or office. The third and fourth years might be similarly divided, the college training being chiefly technical; and the fifth year might be spent entirely in the works or office. In this way the whole time of five years would be equally divided between the college and the works or office, and at the end of this time the student might be considered to have received a thorough general engineering training, with specialisation to some extent in one of the branches.

In establishing such a course many difficulties would arise, but I am fully convinced that they can all be overcome. The system would not be a complete innovation, inasmuch that it prevails to a large extent in Glasgow, where the University session lasts for five or six months, and the student may go into works for the remaining six months, or take a summer session; and year by year more firms "take half-timers" into their works or offices.

Professor Alfred Schwartz, Assoc.M.Inst.C.E., M.I.E.E. (Municipal School of Technology, Manchester), says:—

The reply to the query as to whether the workshop should precede the college course in the training of engineers is, I think, not to be found in any definite pronouncement, but rather in a careful consideration of individual cases.

In addition to the arguments *pro* and *con*, so clearly set forth in your last issue, the following considerations from the point of view of the character and temperament of the student may perhaps be of interest.

If a student is serious and fully realises the importance of his preparation and training, and has had a good general education on liberal lines, I am firmly of opinion that it is best for him to proceed to his college course first, as he will there consolidate and build up the habits of logical thought and careful and accurate observation, the foundations for which have been laid in his school training. He will further be in a position to acquire a knowledge of the properties and strengths of the materials he will have to deal with in the workshop, and of the laws governing the action of the machines with which he will have to do. He will be led to think for himself; and original work in design and investigation will teach him self reliance, and fix in his mind the habit of trying to better the methods and processes with which he is brought into contact. Assuming that he is not a prig—the influence of his teachers and the wholesome criticism of his fellow students should check any innate tendancy in that direction—I am convinced that such a student would approach his work in the shops with qualifications which would enable him to undertake it with far more profit to himself and his employers than if he had proceeded to the shops direct from school. I contend that the schoolboy will miss much of value in the workshop from his inability to recognise the *raison d'être* of many of the processes going on around him, whereas to the college student they will appear in their true light, and from being merely rule of thumb they will have become pregnant with interest. His own attempts at design will have shewn him his weaknesses, and he will be keen to obtain the practical experience and knowledge which he feels he lacks. Again, as he feels his growing manhood, a right-minded youth often chafes at his long and costly dependence on his parents. He will, however, feel more in touch with actualities in the busy work of the shops, and the path that leads to his opening in life is often clearer to him there than if he is then engaged in his college course, having severed his connection with the shops three or four years back.

On the other hand, there are minds that are cast in a practical rather than an intellectual mould, and students of this type I would unhesitatingly recommend to go direct to works on leaving school. Such a student in his college course usually finds the theoretical work difficult, and, failing to understand its import, regards it as academic and useless, and longs ardently for the "practical work" in the shops, which seems to him to be the royal road to success. In the workshop he would be interested, and as he advanced in his work he would see more and more clearly the predominance of the head over the hands. At the conclusion of his time he would be faced with the alternative of embarking on his career with his stock-in-trade of workshop knowledge and manual skill, and a fitter's wages, or of going to a technical college to acquire that knowledge of theory which he would now recognise as being essential.

There is a second type of student who, if intended for engineering, should, in my opinion, proceed direct to works. These are they who, being provided by nature with double-bridged brains, insist on regarding everything from an intensely mathematical standpoint. By being sent into works at this stage they may be saved from speculations on the ultimate constitution of matter, and if they escape being killed may be drawn to applying their powers to the elucidation of problems in connection with engineering work, which otherwise it would have been part of their creed to despise.

Professor Maurice F. FitzGerald, B.A., M.I.M.E,, of Queen's College, Belfast, communicates the following :—

Professor Goodman has written a very useful article, and I am glad to agree in general with what he says ; but may be able to supplement it with respect to the training of civil engineers, a matter he touches but slightly. My own training was somewhat unusual, and it may, therefore, be permissible to refer to it. I had taken my degree in Trinity College, Dublin, before I took to engineering, but having, as a young fellow, no particular fancy for civil engineering, though I had for mechancical, I did not pass through the Trinity College, Dublin, Engineering Schools. Nevertheless, after some six months study of law, I abandoned that pursuit, and entered the workshops of Messrs. Easton and Anderson, at the somewhat late age of nearly twenty-two. Between serving my time, and employment on various works, latterly civil engineering, into which I seemed to gravitate by force of circumstances, twelve years passed, at the end of which I was appointed to the post I now hold, and am engaged in teaching civil, as distinguished from mechanical, engineering.

It is often observed that every man is liable to what may perhaps be called, in Baconian terms, an "Idol of the Way" ; that is to say, he is apt to think that the way by which he came to be what he is, is the real, true, genuine and best way. If he was a classical English public school boy and an Oxford man, that is the way ; if he started as office boy, and "polished up the handle of the big front door," that is the way, and so on, to become a successful engineer. This fallacy of the way is difficult to discount in the case of successful men, and if, to avoid the pessimism of the unsuccessful, we apply to the middling sort of man, we find him too often vague, and disposed to advise rather what is easiest, than what is best, in each particular case.

WORKSHOP SERVICE BEFORE COLLEGE.

Regarding the necessity for this, it is undoubtedly of little comparative importance for civil engineers. This is especially the case with boys of fifteen to seventeen, who, especially when they are clever, are too often overworked at school, and physically unfit for thorough-going shop work ; moreover, the development of a boy's true bent or inclination frequently occurs at a later age, and I am inclined to think that this is so more frequently with civil engineers than mechanical. I have no doubt of the extremely high value of shop training for a civil engineer ; no one who has been through that mill, and ground, thinks otherwise. I believe, but it is not always attainable, and should be preferably taken after a college course by the civil engineer.

WORKSHOPS FOR CIVIL ENGINEERS.

If a man's work is to be principally or wholly connected with railways—excluding the locomotive and carriage departments, with harbours, canals, and a number of other such things, it is neither possible nor necessary that his proficiency in mechanical engineering should be equal to that of one who is employed in an engine works, an electric light station, or a cotton mill. In my opinion it should be regarded as desirable, but not at all imperative, that a civil engineer should, at some period, pass through a short course in the shops. College or institution workshops have, perhaps, more value in this case than in that of mechanical engineers, but in any case their value is far less than a thorough training in physical and engineering laboratory experimental work, because it is by the latter and not by the amateur handicraft of the college workshop that the student is trained in properly appreciating the significance of the results of what he sees happen when certain things are done ; his attention is expressly directed to the parts of the apparatus or mechanism employed and their functions and general habits of correct inference, and of avoiding the error of looking at the means and the product as a confused whole, are corrected.

DIVISION OF LABOUR IN TEACHING.

It may be that I am myself indulging in an "Idol of the Way," partly because it was my own way, and partly because in Queen's College, Belfast, it is not the duty of the professor of engineering to teach mechanics or physics, but it seems to me that the men who have been well grounded in mathematics and mechanics by teachers who make no special point of engineers' purposes in their teaching, are better than those who have been worked up in these subjects through teaching having engineers' purposes in view throughout. Such conceptions as shear and bending moment were absent, for instance, from the mechanics I learnt at Trinity College, Dublin, but "Stoney on Strains" (as the book was then named) gave me no trouble, when I read it by myself, during my apprenticeship ; the gins and snares which beginners fall into in their mechanics, were for me, and I think are generally the better for being kept as few as possible at first—the additional ideas give no trouble afterwards. It is easy to contemn the old paper problems on the equilibrium of thin rods in hemispherical bowls, and such like, when mechanics has been learnt to better purpose afterwards, but I do not think that they are really more to be despised than a child's exercises in simple addition or multiplication. There is, I think, too much tendency now to assume that all teaching of mathematics and physics should keep engineering, particularly mechanical engineering, broad in view. The [illegible] of our ordinary ways are heinous enough, but there [illegible] of amending some of the old ones, by falling [illegible] ones, if a suitable division of labour, among th[illegible] and separation of age at which things are learnt, in the individual student, are not maintained.

ROUGHNESS AND DIRT

Unkind people might perhaps say it is because I am Irish that these gave me no acute trouble in the shops; but I think everyone should be trained to the distinction between clean dirt, the necessary mess and blackness of the workshop, or of the football ground, and dirty dirt, which is defined as matter in the wrong place. There is, however, another kind of dirt, moral dirt, which many people think is more likely to be picked up in the shops than elsewhere, and this is in reality a much more serious matter. Age cuts both ways to some extent, for the young man of twenty must have more freedom, and usually more control of money than the boy of fifteen or sixteen; but, on the other hand, assuming him well principled, the elder has more sense and strength of character. If his social grade be above that of his shopmates, the avoidance of low (in the true sense) associates is actually easier than if they belonged to his own grade; and one must unfortunately not forget that low persons can be found in any crowd, fashionable or unfashionable, easily enough. There is, however, a distinct risk with the boy, that though his actual moral principles will not be corrupted, his qualifications to be reckoned as a properly civilised person may be quite definitely injured by service in the shops. This is not a mere matter of "grit" or principle. A boy who is energetic and loves his work may have a constitutional inability—perhaps owing to a musical ear—to avoid learning bad habits of speech; or he may have an imitative tendency to inferior habits of other kinds, or into a crude asperity of manners, or "lumpishness" of general style which, whether developed or checked by shop training, takes a form rendering him unsuitable for the sort of position he ought to occupy later in life, owing to the treatment being, so to speak, unsuited to the case.

Different places, and different shops in the same place, differ much in their influence in these respects, so that care is required in considering the place he is sent to, as as well as the boy's propensities. The thing that may safely be left out of account, is any fear that the shop service is not genteel enough—but, indeed, present fashion tends to create such fear of being thought to favour gentility, as to occasionally obscure the fear of becoming ungentlemanly.

INITIAL QUALIFICATIONS.

The physical strength and energy necessary to go through shopwork are not so essential for a civil engineer's training; but a man will be undoubtedly severely handicapped by such defects as marked imperfection of sight, or by such delicacy of health as interferes with field work, or with the general ability to live in a rough way in very primitive and often uncomfortable quarters when on outside work—the man who cannot go and live at, say, a reservoir dam under construction because it is in a remote mountainous place, where the best lodging is a poor farmhouse and he dare not run risks in catching cold, will lose much of the best training he might get. He must have sufficient interest in his work to be able to keep himself when out on such work, and not spend all his days reading novels or smoking in the office hut, nor yet in fishing or otherwise enjoying the bounties and beauties of nature.

He is not expected to be a useful hand with pick and shovel, but he will find that it will conduce to keeping his interest in affairs alive, to do a good deal of very subordinate work in conveying messages, even, and lending a hand freely in pulling and hauling and such like matters.

This, however, is post-collegiate work. His intellectual ability should be at any rate fairly good in mathematics, and his fingers should not be all thumbs, nor his tastes particularly studious, and he should possess some aptitude for drawing—artistic faculty is not necessary except for an architect, and is often quite small where the power to draw things either from memory or from nature, is quite marked.

The things he will learn in college which are most useful afterwards, besides the natural sciences, are drawing, the mechanics of structures, and the use of instruments employed in surveying. He will not be turned out a quick or accurate surveyor, by any means; but he will have had the tools in his hands to adjust, use, and misuse, perhaps, in a way wherein the office would not like to see an expensive instrument handled. He will also have had some rather imperfect practice in taking out quantities. The combination of quickness and accuracy is not attainable in a college in this matter, any more than commercial efficiency in mechanical engineering processes, but the tendency of the inexperienced man to work small sums of every sort all over his paper, and put down his final results in large letters at the foot, engendered by examinations, where he knows the examiner has the answer and looks to that first, is corrected to a certain extent. Laboratory practice, where the steps of, and evolution of, the results have to be regularly noted, now tends to introduce a systematic habit of working things so that figures can be checked throughout, which used to be conspicuously absent.

AMERICAN RÉSUMÉ.

BY OUR NEW YORK CORRESPONDENT.

NEW YORK, 10th December, 1902.

Oil Burning on Locomotives.

THE practice of the Southern California division of the Santa Fé Railroad, in the matter of the use of crude oil on all locomotives, was described by Mr. W. J. Wilcox before the December meeting of the American Society of Mechanical Engineers. The oil, which has an asphaltum base and costs $6 per ton, is stored in a seven-gallon tank placed within the water tank on the tender. The oil tank is supplied with steam coils for warming the oil, and is connected with the air reservoir, as three or four pounds is sometimes necessary to obtain a free flow of oil. The oil is led to a hot box, so called, under the engine deck, where it is heated by steam, and from which its flow is regulated by the fireman. The Booth burner is used, 12 in. long and 4 in. wide, having two passages, one for oil and one for steam. The outlets are 3 in. by $\frac{1}{2}$ in. for the oil, and $3\frac{1}{2}$ in. by $\frac{1}{32}$ in. for the steam, the latter below in order to carry the oil with it. The burner is placed under the mud ring at the back of the ash-pan, which has a false cast-iron bottom, through which the air is received. The fire-box has no grate, but both fire-pan and box are lined with firebrick on all sides as high as the flues, and a brick arch extends from the front wall about one-third the length of the fire-box. The fire door has a hole in its centre, through which the fireman cleans the flues when they become clogged with soot by means of sand handled from a big-mouthed funnel having a spout at its bottom. The sand is drawn into the flues by the exhaust. The engines average about thirty miles on freight and fifty-five miles on passenger service to one ton of oil.

Pump Suction Air-Chambers.

The importance of providing ample air chambers on the suction of pumps was referred to by Mr. J. T. Wilkins in an excellent paper on rotary pumps, presented at the same meeting. In the case of two 25,000-gallon rotary pumps, direct coupled to lift 31 ft. at sixty-seven revolutions per minute, two air chambers were furnished on both the suction and delivery sides, with 7 in. connections to the pump. At fifty revolutions a powerful water hammer developed, and by attaching an indicator to the discharge 18 ft. below the upper water level, it was found that the pressure varied from five or six pounds vacuum to thirty or forty pounds pressure. The action on the suction side was similar, the vacuum amounting to twelve pounds, and the pressure slightly above atmospheric pressure. The trouble was completely overcome by additional air chambers.

A 44-foot Pit Lathe.

Another interesting paper at the December meeting of the American Society of Mechanical Engineers, was that by Mr. John M. Barnay, describing a lathe in the construction of which 480,000 pounds of cast-iron were used. It has a face plate of 30 ft. in diameter, made of twelve segments, and is located in a pit admitting of swinging 44 ft. on centres, with a maximum width of 12 ft. The smaller face plate is cast in one with the forward section of the spindle, which revolves in a bearing 48 in. in diameter and 68 in. long. The machine is driven by an 18 in. friction roller made of compressed paper, run upon the rim of the large face plate, which is 15 in. wide. A seventy-five horse-power motor is used, quadruple geared.

Diffusion of Light through Windows.

According to Professor Charles L. Norton, of the Massachusetts Institute of Technology, windows of the type now common in mills, workshops or schoolrooms, fitted with plain glass, if reglazed in the upper half only with ribbed or prismatic glass, will yield on a bright day more than fifty per cent excess of effective light, or on dark days a larger ratio. This conclusion has been deduced from a number of tests made at the Insurance Engineering Experiment Station of Boston.

An Economical Mill Engine.

A 16-in. and 40-in. by 48-in. Cooper Corliss engine at the Atlantic Mills, Providence, R.I., developed, with reheater coil on, an indicated horse-power of 11·22 pounds of steam, including the steam condensed in the coil, no correction being made for superheating at the throttle valve (which amounted to forty-four degrees). With jacket and reheater coil off, the steam consumption was 11·293 pounds, and with jackets and reheater coils all on, 11·406 pounds. The *Engineering Record* gives the detailed report of the tests.

Shipbuilding Industry.

Judging from the annual report of the Commissioner of Navigation, the prospects for the succeeding year in the matter of shipbuilding are not so good as they were twelve months ago. Few contracts of importance in merchant construction have been made, except a number for oil-carrying steamers, and while there may be very nearly as much work throughout this year as there was last year, it will have to be charged largely towards the completion of vessels under construction. The gross tonnage of ocean steel steamers of 1,000 tons or more, building or under contract for the year ending June 30th, 1903, amounts to 200,615, comprising twenty-five vessels, and including four vessels of 26,800 tons. So much for American shipbuilding. In Canada an important concession has been made by the Government benefitting Canadian shipbuilders. Hereafter foreign-built vessels of British register, not already in the coasting trade, can now enter it only by paying the vessel duty provided for in the tariff.

Naval Ordnance.

One of the most interesting points in the annual report of the Chief of the Bureau of Ordnance covers the data regarding the 7-in. 45-calibre guns, twelve of which are to form the intermediate battery of each of the battleships *Louisiana* and *Connecticut*. The gun, which was designed to give a muzzle velocity of 2,900 foot-seconds to a 165-pound projectile within the limits, in chamber pressure, of seventeen tons per square inch, has been proved to a muzzle velocity of 3,035 foot-seconds with a chamber pressure of 16⅓ tons. The *Baltimore* and *Newark* are being re-armed with 6-in. 45-calibre guns, and on the British-built cruisers, *New Orleans* and *Albany*, the Armstrong guns are to be replaced by 5-in. 50-calibre rapid-fire guns.

Submarine Boat Trials.

The submarine boat *Adder*, on a recent official trial, averaged 8·5 knots an hour when running with all her submersion tanks empty, eight knots in the awash condition, and 7·5 knots when totally submerged, exceeding her contract speed. The boat is 63 ft. 4 in. in length, 11 ft. 9 in. in diameter, and displaces, when submerged, 120 tons. It has a single screw, and is driven by a four-cylinder 160-horse-power gasoline engine when running on the surface, and by a 70-horse-power motor when submerged, the motor being driven as a generator when the boat is at the surface, to charge the storage batteries. She has a double bottom and three water-tight compartments.

New Designs of Naval Vessels.

At the recent meeting of the Naval Society of Architects and Marine Engineers, Rear-Admiral F. T. Bowles, chief of the Bureau of Construction and Repair, Washington, presented a paper on new designs of naval vessels. With a view of cheapening construction, the number of structural shapes in the battleships has been reduced to twenty-four, each size of angle bar being counted as a separate shape. Channel bars are used for beams and bulkhead stiffeners. The contract period of construction has been placed at forty-two months. To show the advantage of increase in size adopted, he compared ships of practically the same speed and those of which the motive power and battery are substantially of equally modern design. The *Alabama* and *Maine* class, the most recently completed ships, with 12,000 tons displacement, cost $6,000,000 each, while the *Connecticut* class of 6,000 tons, cost $7,500,000. The weight devoted to battery and ammunition in the former class is 1,003 tons, and in the latter 1,340 tons, so that by increasing the displacement 33 per cent., there is a corresponding increase in weight of armaments. The weight of the discharge of one round from all the guns of the *Alabama* class, above six-pounders, is 5,312 pounds, whereas the weight of the discharge of the guns above six-pounders of the *Connecticut* class is 7,856 pounds, or an increase of 47·9 per cent. In the *Alabama* class the weight devoted to armour protection amounts to 2,770 tons; in the *Connecticut* class to 3,992 tons, an increase in protection of 44 per cent. for an increase in size of 33 per cent. According to model basin trials, at a speed of eighteen knots the *Connecticut* requires 6 per cent. less speed than the *Alabama*; and at nineteen knots, nearly 50 per cent. less than the *Alabama*. In a similar way, comparing the *Tennessee* class of 14,500 tons with the *Pennsylvania* class of 13,680 tons, for the increase of 6 per cent. in displacement, the increase in weight of guns and ammunition is 29·7 per cent.; in the weight of one discharge of the battery, 47·4 per cent.; and in the weight of protection, 30 per cent.

Iron and Steel.

The condition of the iron and steel business on December 1st is practically what it has been during the whole month of November. There is a great shortage of pig-iron and steel, due both to fuel shortage and to lack of railroad facilities, and there is a great over-production in merchant pipe, tin plates, sheets and wire products. So congested are the railways that coke cannot be supplied to the furnace men, and many furnaces have consequently been blown out until more than an irregular intermittent supply of coke is assured. While the constituent coke producers of the United States Steel Corporation have made a fixed price of $3 on coke, in accordance with the policy of that organisation to maintain everything at prices that will tend to keep business in a steady condition, independent coke manufacturers have placed orders for the whole of 1903 at $4 and $4·50, so uncertain is the coke outlook. Prices of $8 and 14, indeed, for foundry coke at the ovens have been announced. By way of statistics, it may be stated that on November 1st the active blast furnace capacity in operation had dropped 7,500 tons weekly from 345,000 tons, the weekly capacity a month previous.

In the case of the merchant pipe, tin plates and products suffering from over-production, the Steel Trust has made a substantial reduction in prices, while supplying steel, in which there is such a shortage, at prices even below the stated market prices. The over-production mentioned is not due to a decrease in purchasers, but to an enormous increase in productive power; this productive power is, to a large extent, in independent hands, so that the price reduction is likely to press the latter, except where raw materials are controlled. It is stated, for example, that the total capacity of sheet mills in the United States amounts to about 975,000 long tons, with 500,000 tons in independent mills, against 500,000 tons total in 1901; and the total capacity of tin-plate mills amounts to 735,000 tons, with 200,000 tons in independent mills, against 400,000 tons total last year. One of the most active branches of the business is the plate trade. Steel rails are also in very heavy demand, orders having been placed for the whole of 1903, and no promises being made to deliver new orders before September. The influence of the railroads on the steel and iron market threatens to become more pronounced owing to increased freight rates, which promise to follow a 10 per cent. rise in wages, accorded generally to railroad employees. The high rates will tend, at least, to raise the prices of castings throughout the country. In foreign business the volume of importations has remained about constant ever since the reduction that occurred about the time when the Philadelphia customs authorities held up a German shipment in October. While it has been decided that the German home market price, and not the special German export price, must prevail in this trade, it has also been decided that the price is not greater than 1 cent. per pound, and the tariff rate of 0·3 cent. per pound applies just the same. Except where forced, however, the prices are considered too high to warrant general foreign purchases. An interesting event in the importations is the advent of the Belgian manufacturers into the Southern States for structural shapes, bidding for contracts for early delivery involving penalties.

The present status of the export and import business of the country can be well shown by the following figures issued by the Bureau of Statistics of the Treasury Department. For the nine months ending September 30th, the value of iron and steel exports, including machinery, amounted to $73,351,735, almost $3,500,000 less than that for the corresponding period of 1901, and about $24,000,000 less than that in 1900. The great decrease was in rails, amounting to 203,652 long tons. The value of imports for the nine months of 1902 was $27,842,949, almost double, 198·1 per cent. of the value for the same period in 1901. The increase lay chiefly in pig-iron, 305,441 tons, and in steel billets, 184,222 tons, the total importation of these materials being 339,406 and 189,975 tons respectively.

Electric Treatment of Iron Ore.

Of a number of recent ventures in the use of electricity for concentrating and reducing iron ore, the most conspicuous is probably that of the Salisbury Steel and Iron Company, which has been formed to develop, in Herkimer County, N.Y., some 320 acres of iron ore lands, which have been found to hold an ore carrying 62 per cent. metallic iron. Part of the operations to be carried on is a concentration of the ore by the Ruthenberg process, patented by Mr. Marcus Ruthenberg, of Philadelphia. The magnetic qualities of the raw material, which is agitated by a sort of screw, are turned over and over and lifted at the same time up a short incline by means of a revolving electro-magnetic field, placed underneath the incline. Passing the top of the incline, the iron particles thus separated from the tailings fall through a discharge chute. A Ruthenberg electric furnace is also to be installed for the reduction of the concentrates for use in blast furnaces. The furnace consists of two chambers, which are suspended closely together, but electrically insulated from one another, each holding the raw materials, each wrapped about at the upper part by an electric coil to magnetise both chamber and contents, and each connected to the terminals of an electric circuit. The discharge from each chamber takes place from an opening in the bottom, the two opposite one another, and the magnetic field produced by the electro-magnets tends to close the gap while the electric current maintains a fusing arc. The fused product drops from the gap in the form of globules or irregular lumps.

A New Photometer.

A new photometer for use as a simple photometer, for any undirectional measurements, such as occur in standardisations, ratings and candle-power distributions, as an integrating instrument for the direct determination of mean horizontal, mean spherical, mean hemispherical, and mean zonular candle-power, and as an integrating instrument for the direct determination of the spherical reduction factor, that is, the ratio of mean spherical to mean horizontal candle-power, was described recently before the American Institute of Electrical Engineers by its designer, Professor Charles P. Matthews. It consists of eleven pairs of mirrors, arranged concentrically with respect to the lamp to be tested, each pair of mirrors reflecting on one side of a photometer screen, and of a standard source of light, which is reflected upon the other side of the screen by means of twelfth pair of mirrors, which can be shifted toward and away from the screens until the illumination on the two sides of the screen is balanced. In order to compensate for the fact that the illumination of a surface does not vary exactly as the cosine of the angle of incidence, the mirrors are capable of an initial adjustment to correct for this.

Fogs and Electric Transmission. Fogs have been charged with causing considerable trouble with electric transmission on the Pacific coast. From Santa Monica, California, there is a transmission line extending for several miles along a coast that is subject to thick fogs. It has been found that the electric lines work well in wet weather, but with a dry spell, followed by a fog, poles would become burned off, this probably taking place first by the burning of an insulator pin, followed by the cross arm, which would allow the wire to swing against the pole. The trouble is attributed to dust collecting on the underside of the petticoats of the insulator, to the formation of a paste by the moistening of the dust, and the final leakage of current through the paste. To overcome this difficulty, the pins and the lower part of the insulators are buried in a redwood block 4½ in. deep, with the hole for the insulator of 1½ in. greater radius than the insulator, and the top of the block 2 in. below the wire. So far, it is said, the device has prevented dust and fog drifting in under the insulator.

Beaumont Oil Development. Although much has been written about the new petroleum oil fields, near Beaumont, Texas, no apology need be made for abstracting a few figures from such an authoritative source as the "Mineral Resources of the United States, 1901," published by the U.S. Geological Survey, Washington. The total amount of capital invested at the famous Spindle Top is nearly $4,000,000, and during 1901 the production from fifty-five wells, owned by forty-one companies, was 3,593,000 barrels, in round numbers, for which 17·5 cents were received per barrel at the wells. Eighty-three producing wells were not operated at all. There are indications, it is believed, that the output of the present pay rock on the 125 acres developed will soon be decreased to a point where the wells will cease to flow, when 15,000,000 to 18,000,000 barrels have been taken out. Bailing or pumping will then have to be tried. In this connection it may be well to refer to the composition of the oil, which has been found to consist of about 85 per cent. carbon, 11 per cent. hydrogen, 1·7 per cent. sulphur, and 2 per cent. oxygen and nitrogen. The calorific value averages about 19,200 British thermal units per pound. About 78·5 per cent. of this has been found effective in boilers, so that pound for pound it has an evaporative power of 1·5 as great as ordinary Pittsburg coal.

The Price of Silver. One of the important developments in the mining industry is the low drop that has taken place in the price of silver. As low as 48 cents an ounce has been accepted in New York, and it is asserted in some quarters that a price of 40 cents will be reached before long. The decrease has been a gradual one, due to the diminishing demand both in China and India; in the former case, on account of the Boxer rebellion and subsequent war, and in the latter, on account of the long period of famine and plague. Moreover silver in this country comes very largely as a by-product in the production of copper, lead and even gold, and the marketable amount of it is thus dependent on the demand for copper and lead. The whole case is a reminder of the great and gradual drop in price of copper that has been in progress for some time past.

PAGE'S MAGAZINE

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OUR MONTHLY RÉSUMÉ.

LONDON, 20th December, 1902.

Shipbuilding Returns.

ALMOST as soon as this number of the MAGAZINE is in the hands of our readers, the shipbuilding returns of the year will be coming out. The figures must remain for future treatment, but as far as one can judge at present they will reveal an amount of work done in 1902 not far short of the record year 1901. Had the English yards been as well employed as those of Scotland and Ireland, the 1901 record would probably have been beaten. But the year closes with gathering depression—even in Scotland, where the output has been so good all along, though the new orders booked in November were under 5,000 tons, or only about one-tenth of the tonnage launched. Orders for three new cruisers were placed in December with Palmers Co., Laird Bros., and the Armstrong, Whitworth Co., and the orders for the two large Cunarders have still to be placed. But what are all these among so many? The number of unemployed shipyard hands is increasing, and building costs are decreasing, but shipowners are not in a contracting mood with freights in such a state of depression. Some five and twenty boats were chartered to take pig iron from east and west coast ports to the United States in November and December, and probably about four times that number to take coal across in October and November. What would these vessels have done but for these exceptional demands? What they have done, of course, has been to bear down homeward rates.

Export Coal Duty.

In the matter of coal a good deal has been made of the extent of the shipments this year, and the President of the Board of Trade seems pleased to think that the quantity supplied to the bunkers of steamers in the foreign trade, exceeds that of previous years. But this does not mean good business, and it certainly does mean a loss to the Exchequer in the matter of the export coal duty, which ought now to be repealed as soon as possible. The reasons why the quantity of "bunkers" taken by steamers loading for foreign ports is so large are simple. In the first place, freights are so low that it pays better to fill all available space with coal for steamer's use than to buy coal abroad plus freight and duty. In the second place, all the "bunkers" supplied are not to British steamers, and the capacity of foreign steamers is elastic as between coal hole and cargo hold. And, in the third place, there are—well, say, "smart" men—among even shipowners, who find it not difficult for a vessel to have on arriving abroad a good deal more "bunker" non-duty-paid coal on board than she requires, and to snatch a ready market for the excess quantity under the margin afforded by Sir Michael Hicks-Beach's tax. A good many erroneous ideas may be assimilated by a casual survey of the coal exports.

New Vessels for the Cunard Company.

While the shareholders of the White Star Company were cashing Messrs. J. S. Morgan and Co.'s cheques for four millions, in part payment of the White Star steamers taken over by the Morgan Combine, the Cunard Company were considering the tenders from selected shipbuilders for the two new boats to be built in accordance with the agreement with the Government. No complete specifications were sent out, and the details given were few. The boats are to be 750 ft. long, 76 ft. broad, and they are to attain a sea speed of 25 knots upon a draught not exceeding 32 to 32½ ft., so that they may not be shut out of any available harbours. Each builder defines the power necessary for the desired speed, which may be from 50,000 to 60,000 i.h.p. For comparison it may be mentioned that the biggest ships of the White Star line are 700 ft. long and draw over 32 ft. when fully loaded, while their displacement is close upon 30,000 tons. These, however, are not such fast boats as the new Cunarders will be. The *Kaiser Wilhelm II.* is 706½ ft. by 72 ft.; the *Deutschland* is 681 ft. by 67 ft.; the *Kronprinz Wilhelm* is 663 ft. by 66 ft.; the *Kaiser Wilhelm der Grosse* is 648½ ft. by 66 ft. The *Deutschland* and the *Kronprinz Wilhelm* have 36,000 i.h.p., and have steamed 23½ knots. The *Kaiser Wilhelm der Grosse* has 30,000 i.h.p., and has steamed 22¾ knots. The new German boat now building is to have 40,000 i.h.p. and is expected to steam 23½ to 24 knots. The Cunard's present largest boats, *Campania* and *Lucania*, are 622 ft. by 65¼ ft., and, with 28,000 i.h.p., have steamed 22 knots.

United States Shipping.

The United States Secretary of the Treasury, in his report to Congress, says that American shipping was greater at June 30th last than ever before in United States' history. The total tonnage built in the year was a trifle less than in the previous year, but in nature of material and wages the shipbuilding in progress during the year exceeded all records. Mr. Shaw, however, says that the growth of American shipping has been entirely within the domestic trade, and that the tonnage registered for foreign trade is smaller than a year ago, though more efficient in having a larger proportion of steam. We learn from other sources that there are at present twenty shipbuilding firms in the United States engaged on Government work, and eight who have only merchant work. On the Great Lakes there are five shipbuilding concerns with merchant contracts. That makes thirty-three firms at work, and there were besides five concerns with no building work on hand at all during the month of November. The total tonnage building in America was 171 warships and merchant ships of an aggregate of 617,370 tons, or only about 120,000 tons or so more than were building at the same time on the Clyde alone. Of the American tonnage named, 104 merchant vessels represent 347,480 tons, and 67 warships represent 269,890 tons. And of the merchant shipping building, 217,000 tons are for the coasting trade and 130,[illegible] for the foreign trade. This latter item includes, it is stated, seven vessels, [illegible] 70,000 tons, for the Combine. Ameri[illegible] over 10,000 tons, two of which are 21,000 tons each, and seven vessels of between 8,000 and 10,000 tons each. We have thirteen vessels over 10,000 tons, and twelve vessels between 8,000 and 10,000 tons each.

A Propeller Test.

Another test in naval steamship efficiency is being made while these lines are at press. The cruisers *Minerva* and *Hyacinth* have been ordered to make another competitive run to Gibraltar, but on an Admiralty, not a Boiler Committee commission. The main object is to test new propellers as against the experiences on the former competitive voyage of these two vessels, on which occasion the *Hyacinth*, with more engine-power than the *Minerva*, made less speed. New screws have been fitted for the test. The workings of boilers and machinery are also to be carefully watched for the Boiler Committee, with a view to correct some irreconcilable records in the report of the last competition. The two cruisers are to steam to Gibraltar at three-quarters power until the bunkers are emptied, each having the same quantity of coal to start with. They are to steam back again at full speed.

Oil fuel for Maritime Purposes.

At the launch in December of an oil steamer for the Shell Transport Company, built by Sir W. G. Armstrong, Whitworth and Co., at their Walker Yard, some interesting statements were made with regard to the future of oil fuel for maritime purposes. Sir Andrew Noble says that his company have been doing much to illuminate the subject, having been engaged on a series of experiments to determine the best form in which oil can be applied to the boilers of warships where high power is requisite from comparatively small boilers. It takes a battleship about twelve hours to coal in favourable weather, but Sir Andrew Noble calculates that with oil a battleship could be refueled in three-quarters of an hour in any weather. This is an important difference, and we await with interest the completion of the Armstrong Company's experiments with warship furnaces, etc.

British Railway Reform.

For some time past a spirit of disquietude has manifested itself among the shareholders of our leading railway companies by reason of the fact that working expenses generally have latterly shown a considerable increase, without a corresponding increase in revenue. It has been suggested that genuine and effective co-operation among railway companies would go far towards securing economical and efficient working of the various lines, and this view is endorsed by the chairmen of several of our leading railways. It is urged that a Special Conference of railway directors should be summoned for the purpose of considering the best means of securing a greater measure of co-operation than that which at present exists. Among the reforms proposed it is suggested that American methods of handling traffic waggons should be adopted in this country, and it is believed in some quarters that much advantage would accrue from the adoption of the American system of railway accounts.

The Waggon Question.

The substitution of goods waggons of larger build and greater freight capacity, for those at present generally in use, from an economical point of view, is regarded by some as totally impracticable and unsuited to the course of trade in this country. Several 30-ton waggons have, however, been recently built for three or four railway companies, and have been found to be most satisfactory. In February last, Sir George Armytage, the Chairman of the Lancashire and Yorkshire Railway Company, reported the success of these waggons in certain classes of traffic to be such that they had ordered fifty more to be built. It is urged that upon the use of larger waggons depends the more effective increase of the train-load, with a resultant economy to capital and revenue. Larger waggons enable goods to be carried in as few trains as possible, thereby reducing the unnecessary congestion of trains, which, in the past, has been the cause of heavy capital outlay on widenings. They diminish the number of locomotives needed to draw the smaller number of trains, thus effecting a further saving of capital and revenue. They reduce the wear and tear of the rolling stock and of the road-bed, thereby reducing the cost of maintenance, and, through a consequent reduction of staff, may be expected to materially reduce the wages bill.

Mineral Traffic. The Board of the London and North-Western Railway, in a recent correspondence with some of their shareholders, stated that the size of the waggons for mineral traffic is, at present, practically controlled by the traders themselves, the natural inference from this being that the traders are opposed to larger waggons, and that the railway company itself has no influence in the matter. This, however, is by no means the case, for the proprietors of many large collieries, steel-works, gas-works, and quarries are quite willing and desirous of using larger waggons. Undoubtedly this reform is hampered by the failure of the Clearing House to revise its old standard specifications, and issue new ones for traders' waggons of a greater capacity than ten tons.

Railway Statistics. In reply to a question put to them by a committee of shareholders, with reference to the adoption of the American system of accounts, the Board of the London and North-Western Railway say, that although the English companies do not prepare statistics applicable to the whole line upon the elaborate basis of the American accounts, all the information which is desirable or necessary is available and utilised for testing the working of their system. The statistics of the English railways, though apparently satisfactory to the Company boards, are not so detailed as those in use in America, and, taking into consideration the fact that American authorities contend that these self-same statistics have contributed largely to securing good results and maintaining their high profits, this admission must be looked upon as one of grave importance. Although the fullest information is absolutely essential to the proper working of the lines, under the present system our railway accounts furnish no information as to:—

(1) The ton mileage,
(2) The passenger mileage,
(3) The train load,
(4) The waggon load,
(5) The engine load,
(6) The length of haul,
(7) The average receipts per passenger per mile,
(8) The average receipts per ton of freight per mile.

From an examination of the accounts of the London and North-Western Railway it appears that, excluding from the expenses rates and taxes as matter beyond the immediate control of the Company, the ratio of expenses to gross earnings in 1870 was 44·16 per cent. In accounts of more recent date that figure has risen to 59·33 per cent. Or, to put the matter more plainly, out of every 20s. received in 1870, the company spent 8s. 10d. Now, out of the same amount, it spends no less than 11s. 10d.; in other words, there has been a rise in expenses of 3s. in the £1.

From these figures will be seen the necessity of precise and accurate statistics for the purpose of locating the actual causes of the increase, and finding out in exactly what sections of the line, in what classes of traffic, in what methods of handling it, and in what division or sub-division of management these causes arise. Until this is done no effective remedies can be applied, nor other methods tending towards economy introduced.

It is suggested that statistics should be published yearly with the accounts, as is the custom in America, such a course being likely to substitute a healthy and useful competition in place of the unhealthy system of freight-snatching now in vogue.

Local Taxation. With regard to the burden of local taxation and other disabilities under which railway companies have to work, little has been done, though the matter has been under the consideration of the Railway Association for some time past. It can hardly be expected, however, that until railway boards take some definite and strenuous action in the matter, any public recognition of claims, however just, or any amelioration of conditions, however onerous, can be expected. In Parliament, municipal bodies, and disseminated among the public generally, there is a strong tendency to be prejudiced against railways, and to ignore the services they render and the difficulties with which they have to contend. It is evident, therefore, on consideration of the fact that legislation is the function of Parliament, rating is in the hands of municipal bodies, and both are, ultimately, under the control of the public, that railway boards are apt to be somewhat handicapped.

Need for Reform.

It is a self-evident fact, therefore, that little or nothing can be done towards increasing the returns of our railways under the present policy of the various boards. Possibly, under the old *régime*, the directors have endeavoured, to the best of their ability, to secure the best results; but their policy should now be more enlightened and progressive and the methods of working more modern and scientific. The tendency of labour is to become dearer, and the price of coal is likely to rise, not temporarily, but permanently; therefore, if our railway boards remain in their present state of inanimation and do nothing to improve matters, they must be prepared to face rapidly decreasing profits.

Air and Electric Rock Drills Compared.

At the Düsseldorf Exhibition there was a special section devoted to rock drills, in which were displayed air and electric drills of makes unknown to most visitors from this country, but that does not matter, inasmuch as we are only going to draw attention to certain points elicited by some carefully conducted experiments. The competing drills all worked on the same block of stone with cutters, chisel ended, of the same pattern, 60 deg., and size 40 mm., and made by the same maker from steel produced from a single forge in Krupp's works. The cylinders were all approximately 3 in. in diameter, and the air pressure the same in each case. Five air drills competed, the lightest weight was 81·5 kilos, the heaviest 122·5 kilos. The quickest bored 1·442 cubic centimetre in the second, and required 16·90 h.p. The lowest h.p. exerted was 10·72, and it bored 0·204 cc. in the second and also exhausted the smallest quantity of air, 2,133 litres per minute. Three electric drills competed, the lightest in condition for transport was 26 kilos, the heaviest 97 kilos; two were diamond drills. In the percussive drill, with 3·73 h.p., 1·361 cc. was bored per second, whilst the diamond drill, with a crown 37 mm. in diameter, required 1·65 h.p., and bored 1·939 cc. in the second; this drill weighed 81 kilos. The lightest of these drills had a crown 30 mm. in diameter, and with 2·09 h.p. bored 1·139 cc. per second. It will be seen that, although the air drills came out ahead in speed, they were far behind, from an economical point of view, in duty and the power required.

Russian Mercury.

For many years the mines of M. Auerbach at Nikitowka have been famous for the production of mercury, and for the curious association of mercury with carbonaceous matter in the mine. These mines are situated near Ekaterinoslav, in Southern Russia, and produce about 340 tons a year, whilst Spain produces over a thousand tons a year, and the United States well under a thousand. But, as rumour goes, the Russian output threatens to be increased by projected activity in the Daghestan territory 900 miles or so to the south-east from Nikitowka. Here, on heights 3,500 feet above and some forty miles inland from the Caspian Sea, are situated the Khpek-Rakhoun and the Gaptse mercury mines, from which the increased output is expected. They are somewhat over fifty miles to the south-west by road from the chief town of the district, Derbend. The mineral is cinnabar, and it occurs in Jurassic country, where sandstones alternate conformably with clayslate; the cracks and fissures in both rocks are mineralised, but the sandstones are also impregnated with the mineral. Thus it resembles some other well-known deposits. These Daghestan deposits have been known from time immemorial, and many attempts have been made with varied success to work them. But now they have fallen into other hands, and more serious work with better results is anticipated. Then the Caucasus will add another success to its list of profitable mineral undertakings, which include already petroleum, manganese, copper, mineral waters, &c.

Separation of Coal and Shale.

In Belgium an apparatus has been in use some time, and has now been proved satisfactory, for the separation of shale from coal without the use of water. The apparatus is of the character of the shaking screen, but is provided with four transverse rows of short longitudinal bars set at an angle to the surface, so, although the screen is inclined as usual, the bars are at a less inclination. They have, in section, the form of the letter A, and are set with the apex uppermost; the result in working is that, owing to the jerking motion, combined with the shape and distribution of the bars, the lumps or pieces get tumbled about, the flat pieces of shale get up-ended, and pass between these bars, whilst the more or less cubical pieces of coal are retained, and roll off in the usual fashion. A preliminary sizing is, of course, necessary, and sizes between 0·8 mm., 8·15 mm., 15·20 mm., 20·30 mm., 30·40 mm., 40·50 mm., 50·60 mm., and above 60 mm. have been successfully treated.

Previous Schemes.

This recalls the Coxe automatic slate-picker. This is fixed, but inclined so that the properly sized mixture of coal and shale or slate slides over it. The surface is corrugated into V-shaped troughs, with one side steeper than the other, and in the steeper side of these troughs slits are cut which widen towards their lower end to prevent jamming. In work the lump coal slides to the end and tumbles off, whereas the flat pieces of slate or shale slip through the slits. The size and taper of the slit, the width of the troughs, the angle and length of this picker vary with the size of the coal and the nature of the shale. The troughs are made little wider than the largest sized lumps fed on to the pickers. In another scheme the coal and shale slide down a smooth inclined plane, and the friction of the coal being less than that of the shale it acquires a greater velocity than the latter in its progress down the screen, hence it is enabled to jump a gap at the lower end, through which, however, the shale or slate falls. The problem of separating coal and shale in places where water is scarce, or when its employment is not desirable, will be encountered to a greater extent in the near future, and, therefore, it is well to note these matters.

The "Sierra de Cartagena."

Worked in early times by the Phœnicians and the Romans, and suffering subsequent neglect, this district entered upon its modern period of activity about 1840, and a few small villages of that time have now grown into the township of La Union, of some 25,000 inhabitants, the whole "Sierra" containing about 40,000. In this district are mines of iron, lead, and zinc ores, lead smelting works, and a few works for the manufacture and repair of machinery and mining appliances.

A number of shallow mines are worked by hand windlasses; or in the case of greater depths by winding drums worked by mules. Water is drawn out by the same means, also by small pumping plants of about 10 h.p. or so, though a few much larger plants have been put down. Some of the ore is brought to the surface at considerable elevations, and is handled by cable-ways; donkeys, with a couple of baskets each are also used, and carry the ore right on to the heaps.

The methods of mining, transport, and loading into the ships have received and are receiving careful attention, and they would be greatly improved if conditions warranted the outlay.

It has been proposed to adopt a general drainage scheme under the law of August, 1889, for a part of the district, some twenty-four square kilometres (9¼ square miles) in extent. The natural conditions are considered to be reasonably favourable, and the mines are near together. A voluntary combination has already failed, partly, at least, on account of disagreement as to the conditions of payment. Under the law a defaulter would only be given two months' grace, and then the mine would be put up to public auction. The promotors consider that they should be given some substantial encouragement by the Government.

NOTABLE BRITISH PAPERS OF THE MONTH.

A Monthly Review of the leading papers read before the various Engineering and Technical Institutions of Great Britain.

INSTITUTION OF ELECTRICAL ENGINEERS.

INAUGURAL ADDRESS.

IN his inaugural address to the Institution of Electrical Engineers, the president, Mr. James Swinburne, invited attention to "Some Limits in Heavy Electrical Engineering." Resisting the temptation to elaborate a dream of the future, the President remarked that they had been going ahead so very rapidly lately—even their acceleration itself increasing—that they might be a little apt to have vague views of what they could and what they could not do electrically. It might be well, therefore, to look over some of the branches of their great and diverse industry ; to see what obstacles were opposing them, and what were likely to oppose them shortly, and to consider whether these obstacles were insuperable or not.

APPLIED AND UNAPPLIED SCIENCE.

A preliminary reference was made to the gap between applied and unapplied science, it being remarked that each branch has its own peculiar advantages, and there ought to be no sort of antagonism.

We, as electrical engineers, ought especially to heal the split between the two halves of science ; a split which is much deeper in 'other branches of engineering, such as chemical and purely mechanical. We ought to unite knowledge of both branches of science in one individual as much as possible. The electrical engineer must not be only an overgrown wireman, a mechanical engineer with a little electrical knowledge, a mathematician, a financier, a lacquered brass and sealing-wax varnish instrument maker, a physicist, or a manager of men. He must be all of these, in different proportions in different people. Our Institution should equally deal with all parts of our knowledge. We ought to have papers on the value and cost of fuel and on electrons ; on the best way of arranging piecework, and on the thermo-dynamics of the dissociation theory ; on the "skin" effect and cylinder-condensation ; on the relation of *c* to borrowing powers ; on Wien's law and the proper charge for lamps on variable circuits ; on the relation of the refractive index and specific inductive capacity and the electro-magnetic theory of light, with special reference to the waste of power in alternating rubber cables ; on thermo-dynamic potential applied to making manure by fixing nitrogen ; Guldberg and Waage's law and gas engine combustion ; on tube railways, Hertz waves, wireless telegraphy, strikes, blast furnace gas, submarine telephony, automobiles, standard cells, tramway cars, and everything that concerns electrical engineers.

THE TIDES AS A POSSIBLE SOURCE OF ENERGY.

Proceeding to deal with a wide range of subject, the President first discussed the tides as a possible source of energy.

The tides are often referred to as a possible source of energy even to this day ; and it is urged that in places where the tides rise abnormally, for instance, in the estuary of the Severn, it would pay to make a dam with turbines. The sort of argument is that if you have an area of, say, 1,000 square metres, and a total rise of 15 metres, you have 15,000 cubic metres of water, and as this runs in twice and out twice a day, you have 15,000 cubic metres of water, falling the equivalent of 60 metres a day ; or, approximately, 100 kilowatts. This statement contains many fallacies. In the first place, in order to get the full advantage of the difference of level, the water must be let in and out at high and low tide only. Even then the equivalent, or average head during discharge or charge, is only 7½ metres. But a system which gave an enormous power for a very short time four times a day would be of no use. The plant would be expensive, and the result of no value. With a single tank it is impossible to get a continuous output. If the tide is coming in, and you get power by letting the tide fill the tank, the power will decrease to zero as the tide begins to fall and comes to the same level as the water in the tank. It is, therefore, necessary to have more than one tank.

To make the plant practical you want fairly constant pressure available on the turbines, though you may waste head by sluices or valves. Then the tank may be divided up into three, one of 200, and two of 400 square metres. The small one is emptied at each low tide and filled at each high tide. Starting at half tide, with the tide rising, and the 200 and one 400 metre vat empty, and the other 400 quite full, the small tank takes in water at such a rate that at high tide it is half full. It thus takes in 1,500 cubic metres of water with a useful head of 7½ metres for three hours. This gives 10 kilowatts. At full tide the large empty tank is allowed to fill through a turbine working on 3¾ metres, but taking twice as much water per minute, and this goes on till half ebb tide. The small tank is rapidly filled to high tide level. At half tide the large tank has 3¾ metres of water, and the head is getting too small, so the small tank is now allowed to empty for three hours with 7½ metres fall, until low tide. From low tide to half tide the second large tank is emptying from the 15 to the 11¼ metre level.

By means of these tanks, of total area of 1,000 metres, and two turbines and one dynamo we thus get 10 kilowatts going into the turbines. If the tide—and the neap tide must be taken—is only, say, 4 metres, we only get 700 watts! No doubt the tanks and turbines might be worked somewhat more profitably than I have sketched, but there can be little margin. Turbines to work on variable pressures, or any sort of storage, mean more capital expenditure, and it is the great capital expenditure that wrecks tide schemes. It is often said that a Norwegian fiord or a Scotch loch could be easily dammed and utilised; but it would be impossible to find three lochs all opening out together. The need for more than one reservoir does not seem to have been recognised. In addition, the demand for electrical energy on Scotch lochs or Norwegian fiords is rather minute.

WATER POWER.

Speaking of the fictitious value attributed to water power, the President remarked:—

Against the cheaper power, we have to put extra carriage for materials and for coal, which is often needed in addition, and extra carriage for finished products, and very often extra cost of labour, as labour is often dear and bad in water-power districts. Let us take, as an example, calcium carbide. The general idea is that the electrical energy is practically the whole cost of the carbide. Taking present practice, however, a kilowatt makes about two tonnes, or say two tons of carbide a year. The difference between water at, say, £2 10s. and £5 a kilowatt year, is thus £1 5s. a ton in cost. The price of carbide may be taken at £13 10s. a ton, so doubling the cost of power instead of nearly doubling the price of the carbide would increase it a little more than 10 per cent. Difference in freight of coal, coke, lime, and carbon, coupled with cost of carriage, may thus easily be of more importance than cheap power even in such a case as making carbide, which is an electrical furnace product in which, at first sight, the power seems to be the main element of cost. In the case of electrolytic caustic and bleach, the cost lies in caustic and the corresponding bleaching powder, the electrical energy, taken at £2 10s. per kilowatt year, a low water power cost, comes to about [illegible]. The caustic and bleach sell for about £16, according to a varying market. Doubling the price of power, therefore, increases the price some 5 per cent. It may, therefore, pay to use much more expensive power if the other conditions are more favourable. Steam power, for instance, will cost 3 or 3½ times as much, and yet it pays to make electrolytic caustic and bleach in England, where the other conditions are all favourable. It is not, therefore, the want of water power that has kept the electrolytic industry back in this country. For a water power to be really valuable, it should be near a source of material, on the sea, and should have a great head of water, so that the capital cost of development is small. Such a water power is very valuable—to the landlord.

A blast furnace is more valuable than a water power. There are plenty in England. But the owners, who have been wasting the gas up to now will not give it away; they will want rent, so that it will only just pay to buy his gas rather than make it. The electrical industry thus does not gain, but the iron-masters do.

DYNAMOS.

After dealing successively with the limits of steam and gas engines, Mr. Swinburne proceeded to discuss the position with regard to dynamos and transformers.

As regards efficiency we have reached the practical limit already, for further reduction in dynamo losses would make no appreciable difference in the total efficiency of a station. In fact, we are rather following Continental practice in having slow-running machines with many poles, even for direct currents, but efficiencies are perhaps lower for large machines than in the best English practice of a few years ago. This is also true as regards output from a given size. We are not likely to make much advance in dynamo design, as we are limited on one hand by the hysteresis loss in iron, which prevents our using higher inductions in armatures, and low permeability, which limits our field and armature tooth inductions. It does not seem likely we will now find iron much better in either respect. Nor are we likely to find a better available conductor than pure copper. As insulator we have mica. It looks, therefore, as if we were within sight of our limits in dynamo and motor designs.

TRANSFORMERS.

In alternating transformers there has been little room for improvement for the last few years. The of the iron was a trouble, but now there seems little possible advance.

SECONDARY BATTERIES.

The secondary battery in central station work has been used as a store to equalise the load, and to reduce the running plant at the times of heavy load. Owing to the high full-load station pressure with feeder systems, the station battery is generally for use at light loads only. But the secondary battery has for a long time been on the border of success for traction work, both on tramways and on the road, and a further improvement in batteries may be expected to produce very great changes in important branches of engineering.

The first question asked is : Why do we stick to lead ? The answer is that the case is very special and other things will not do. We are practically limited to lead, at any rate in acid cells. Take first the plate that oxidises on discharge. It should not dissolve in the electrolyte, as if it does, the deposition and solution will be uneven, and the plate will grow trees and come to grief. This puts zinc out of court, unless some electrolyte is used which gives some insoluble salt of zinc, which does not attack zinc on open circuit, and which gives a good electromotive force with it. Iron is out of court for the same reason ; there is no suitable electrolyte. The strong organic acids such as trichloracetic or oxalic are apt to have their positive radicles split up by electrolysis, even if a strongly positive metal can be found with an insoluble salt. Lead is thus the only metal practically available in an acid electrolyte. Silver in hydrochloric acid would give no pressure, and the acid would be decomposed at the anode. On the other plate we need an insoluble depolariser, else a two-fluid cell must be used, involving a porous diaphragm, diffusion, and impracticability. Not only must the depolariser be insoluble, but it must be converted into an insoluble body on discharge. The coating must be a conductor in one state or the other, or there will be no proper contact. In the lead cell there is always enough peroxide and metallic lead in the coatings to secure electrical contact though the discharge product is an insulator. The depolarising coating must be connected to a conducting plate which is not attacked by local action. Lead and silver are the only available metals, and sulphuric, and perhaps phosphoric, the only acids, for the nitrate of lead is soluble and hydrochloric acid is decomposed by lead peroxide. Lead is protected by its coating of sulphate, or peroxide, as the case may be. It thus seems as if we were limited almost absolutely to lead and sulphuric acid. It is wonderful that we have the lead cell at all. We owe it to the chance observation of Planté. The theory was not understood for a long time. For many years it was thought that the pressure was due to the PbO_2 and Pb changing into PbO. The acid was merely put in to make the electrolyte conduct, and sulphuric was used because people used it in gas voltameters, and they never thought that it ought to be as strong as practicable to give the pressure and output. The formation of lead sulphate was regarded as a difficulty to be overcome.

In the lead cell we want lightness, large capacity, cheapness, rapid discharge, efficiency, and mechanical strength, and durability. These qualities are mostly antagonistic. Large capacity means rapid deterioration. Mechanical strength means weight. It is thus no use testing a cell for capacity without testing the efficiency and durability too, and so on. Published battery reports are often misleading, because they omit essential information.

In an alkaline electrolyte such as caustic, such metals as iron, nickel, cobalt, and copper form oxides which are insoluble. The metals are thus electro-negative in caustic, like gold or platinum in acid. The electrolyte here acts merely as a conductor, as the dilute acid was supposed to act in the lead cell. The pressure is thus chiefly due to the change from metal to oxide on one plate less the reduction on the other, and is small. There may be a Gibbs-Helmholtz temperature coefficient pressure in addition. Though the pressure is smaller, the metals admit of light plates or grids, and the coatings may conduct in both states, instead of only one as in lead cells, so that a larger proportion of the coating may be active. The future of this type of cell is uncertain, as very little has been published as to results. Our limits in secondary batteries thus seem to be settled by the need of having insoluble electrodes and insoluble coatings.

CABLES.

The conductor itself can hardly be improved, but there is great room for improvement in the insulation. It is largely the insulation of the cables that limits our pressures, and, therefore, our distances of transmission. For 1,000 kilowatt cables the cost is about a minimum for 8,000 volts ; above that the cost of insulation increases faster than the cost of copper falls. It is exceedingly unlikely we have reached the limit in insulation. There is no branch of electrical engineering so important as cable making. Cables form a large portion of the capital outlay in large systems. Yet there is no branch of the industry which is run on less scientific lines. The days of secret mixtures known only to the workman who makes them may be passing away ; but even now the whole art of cable-making is a question of trial and error, with a good deal of the last component. Engineers do not know now whether rubber is better than paper, nor can they tell what any particular -make of cable will be like after ten years' use. We do not even know how to test a cable. Sometimes we test it as if it were a telegraph wire ; at other times we test with twice the maximum pressure, and if it does not break down, we trust we have not injured its constitution, and put it down, or we break down a little bit and assume it will all stand some proportion of the break-down pressure.

Apart from resistance to rupture and leakage, capacity and dielectric hysteresis are important factors. In alternating work capacity may produce very unexpected effects. In series with an arc, say at a switch, oscillation may be set up. When condensers were made at Teddington they were sent out with printed instructions to avoid switching off. They had to be switched off in shunt to or in series with a resistance. The loss of power by dielectric hysteresis has again been discussed recently ; and whatever its exact amount may be in different cables, it is often a very serious factor. We do not seem to have arrived at anything like the lower limit of this yet.

Overhead bare conductors for very high pressure are not used in this country. There is a fairly definite limit to the pressure available. When the fall of pressure, or dielectric stress just round the wire, exceeds the breaking-down value of air, the air is "torn" and discharges take place which involve considerable loss. This can be reduced by increasing the size of the conductor. It may thus pay to use aluminium or even zinc, or a combination for very high pressure overhead power transmissions. If zinc falls in price much relatively to copper, it may come into use for bare conductors.

LIGHT.

In the course of his observations under this head, the President remarked :—

Our chief work, until lately, has been producing light. Here the inefficiency and waste is prodigious, and though it is mostly unavoidable, there is still great room for improvement. We take great care over our stations, watching every penny from the coal shovel or mechanical stoker to the station meter. We quarrel over 1 per cent. in the generators. When we get to the mains we care less, and once we have got to the consumers' meters we care nothing at all. . . .

There is no thermo-dynamical reason why electrical energy should not be converted directly into radiation of any wave-length without loss ; I do not know if there is any molecular impossibility, but apparently our limits are practical—that is to say, it may be done, but we have not yet hit on the way of doing it. The vacuum tube appears to be a means of converting electric power direct into radiation. The Cooper-Hewitt lamp, for instance, gives an efficiency of about three candles per watt, or something like 0·6. All these figures as to light are a little vague. Unfortunately, the light is of a very bad colour. It is very actinic, but the wave-lengths are too small. One method is to degrade the light by making it act on silk dyed with matters which lower the radiation to a redder colour by fluorescence.

THE ARC LIGHT.

The whole question of the physics of the arc deserves far more careful study than it has yet received, but the work is surrounded with difficulties and is really a branch of the theory of the passage of electricity through gases, a matter of the greatest scientific importance, somewhat out of our way as practical electrical engineers. But as engineers in the broader sense we are as much interested in questions of recondite physics as of costs of generation.

Looking at the arc as analogous to a vacuum tube with no vacuum, but very hot and very rarified gases instead —a difference in degree, not in kind—the question arises whether we can get direct conversion into radiation without intermediate heating. The enclosed arc seems to give us something of this sort. It is difficult to see what goes on inside the inner globe, but the arc itself, apart from the crater, seems to give more light. The efficiency of an enclosed arc is much reduced, however, by the deposit and globes. Hot vapours, such as that of metallic salts in the Bunsen flame, give out light by direct action, not because they are hot, but by some chemical change, and this holds good of vapours in vacuum tubes, and doubtless also in the arc. In an enclosed arc the carbon vapour instead of combining with oxygen may first condense at the temperature of the crater, forming a luminous envelope round the arc itself. By mixing suitable salts with the carbons we may thus expect to get electrical power converted directly into radiation.

It has long been known that adding sodium salts to the carbons increases the light, perhaps without improving it, but such experiments have been carried out rather empirically, and apparently without any distinct idea of direct production of light. Recently great attention has been excited by the Bremer arc lamp, which owes its effect to the addition of salts to the carbons. Another recent development is the arc between pencils of oxide, such as zirconia. This arc, which was tried, if I remember right, about 1897, has come to the front again. It may depend simply on high temperature, or on small amount of shadow from the lower electrode, or it may be that zirconia volatilises and condenses as a luminous cloud outside the arc, giving a light like burning aluminium or magnesium, or the hot vapour may also be giving the zirconium emission spectrum in addition. I have not seen this light.

To sum up as to the arc light, we do not seem to have reached our limit as to light from pure heating, because we lose a lot of light into the opposite carbon. Many attempts have been made to expose the crater freely. But, far more important than this, I would urge that the arc is not necessarily a hot body radiator only, but that it may also convert electrical power directly into light in the space between the electrodes, and this gives a chance of rising more nearly to our theoretical limit of about five candles per watt.

THE INCANDESCENT LAMP.

An interesting section of the address dealt with the incandescent lamp.

This simple hot carbon wire in a bulb involves the most extraordinary physical complexities. A great many curious things go on inside the simple-looking globe. A good account of what is known—especially since he took the subject in hand—has been written by Dr. Fleming, and the scientific manufacture of this interesting article has been fully described by Mr. Ram. The incandescent lamp is a simple hot body radiator, and the limit of efficiency depends chiefly on the temperature of the carbon. As we are limited by the size of mains, we can only use pressures of 100 volts or 200 volts, and this limits us to carbon, or something of still higher specific resistance. The high pressure is bad for the lamp in every way. The carbon has to be longer and thinner, and therefore weaker, while the great pressure between the ends of the carbons gives rise to [illegible] across the hot interval. The high pressure [illegible] that the surface of the carbon is worn away [illegible], and that the carbon is thinner and less able to stand it. Inherently a high pressure lamp is worse than a low, but the convenience as to distribution outweighs this disadvantage. The limit of efficiency of incandescent lamps is chiefly due to variations of supply pressure, [illegible] is beginning to soften at ordinary lamp temperatures, and the upper limit is soon reached. So that, though a lamp may give a third or even half a candle per watt when run steadily, it has to be rated at a quarter to make it safe under ordinary conditions. The sensitiveness of the carbon lamp to pressure in its turn limits the practical variation of pressure of supply, and thus costs us very heavily in mains. If we had incandescent lamps which did not mind 20 per cent. pressure variation, we would have saved millions in mains in this country alone. Recently the demand for "ballast" for the Nernst lamp has led to the introduction, for that purpose, of little bulbs containing fine iron wire heated to the critical point. This "ballast" may be used in series with the incandescent lamp.

Other materials have been proposed instead of carbon. A great deal of work has been done on metals, but they have the great fault of low specific resistance. Even osmium seems unlikely for 200 volts. The specific resistance of metal goes up very quickly near the melting-point, but even then it is too low. I have worked a good deal at this problem, but unsuccessfully so far. Most of the metals generally called infusible are not nearly refractory enough. It is quite easy to melt such things as tungsten and molybdenum into globules at the temperatures necessary for high efficiencies. To oust the carbon lamp a great advance in temperature is necessary. I have found a metal that seems refractory enough, but it has too low resistance, and there are very serious difficulties in making wires of it. It would seem that black oxides ought to make good filaments. Most of these substances melt easily. They conduct when first made, and go on conducting when hot. But, if then allowed to cool, it will be found that they have undergone a change and no longer conduct. The black or brown oxide of vanadium is a good example of this.

The idea of making lamps of carbides has become very fashionable lately. People have put oxides into carbon for the last twenty years. The old idea is to get hold of an oxide that radiates more light at a given temperature than it ought to, which is itself a fallacy, while the idea of oxide in contact with carbon is chemically absurd. There is no oxide irreducible by hot carbon. The carbides are not by any means all refractory. Some are, though, but there are immense difficulties in making carbide lamps. I have made low resistance carbide lamps which stood high temperatures, but that is a very small step on the way. Mr. W. H. Story has gone on with this, beginning where I left off. After two years' solid work he has made no carbide lamps, but I believe he will eventually. To make a fine filament material of an infusible material, which can be made only at electric furnace temperatures, and which is generally decomposed by moist air, is not an easy task.

It is easy to think you have made a carbide lamp by incorporating an oxide in the filament material, but the resulting filament is generally mostly, if not wholly, carbon. What happens to the metal under the circumstances is rather a mystery. There is, however, a chance of enlarging our limits in incandescent lamps of the ordinary kind, but it seems strange that the melting points of all known materials should suddenly reach a higher limit. Assuming the Stefan-Boltzmann law for ordinary light radiations, the fact that the efficiencies of refractory bodies all reach limits of the same order shows that the most refractory bodies melt at about the same temperature, somewhere in the neighbourhood of 3,000 deg. A. As melting points are dotted along the temperature scale from 16 deg. A. for hydrogen, and something lower, not yet determined, for helium and bodies ending in "on" up to about 3,000 deg. A., we might expect some to go up to 4,000, 5,000, and so on. Whatever the intermolecular forces may be that bind the particles to make solids, the vibration forces due to temperature seem to overcome the greatest at about 3,000.

Instead of an ordinary conductor, Nernst uses an electrolyte which stands a higher temperature. The conduction is electrolytic, as can be easily shown, but there are many curious phenomena, many of them so far unexplained, in the Nernst lamp. The efficiency of the Nernst lamp is about 0·6 candle per watt. It was at one time supposed to owe its efficiency to selective emission, but there is no reason to doubt that it is a pure temperature radiation. It might be said that as a vacuum tube and a Nernst glower both conduct electrolytically, both being transparent, the Nernst may work by direct conversion of electrical power into radiation; but it does not work in this way, at least not mainly. Emissivity seems to vary with temperature in the case of solids and liquids. A transparent, that is to say a non-absorbing, gas does not radiate when heated, but a transparent solid emits when hot even those rays which it does not absorb when cold. Recently some writers have treated the ordinary carbon filament as being transparent when hot. If it were transparent it would not follow the cosine law, but it also would have to conduct electrolytically.

The idea of carbon conducting electrolytically is too extreme to be entertained. It is difficult to say how the idea of the transparency of hot carbon has arisen. Perhaps carbon does not behave as a "black body" because it is not quite black, and because its index of refraction is widely different from that of a vacuum, so that it may depart from the law of cosines and look brighter in the centre, as if transparent. The Nernst lamp, however, gets us nearer our limits both by high temperature and high pressure, so that it pushes out the limits of constant pressure distribution. One difficulty in the electrolytic lamp is to get the material to conduct at a low enough temperature, and to stand a high temperature too. The Nernst lamp is essentially zirconia, which stands a high temperature. A little basic oxide of the yttria group is added, and there is probably formed a portion of zirconate of these metals, which is fusible enough to conduct at a lower temperature. This subject needs elucidation, as the zirconates are probably like the silicates, forming a long series. Moreover, zirconia and yttria in the proportions for simple zirconate form a very infusible material. The whole subject is very obscure. We cannot say we have got anywhere near our limits of high temperature efficiency of running, low temperature in starting, or high pressure in the electrolytic lamp.

RAILWAYS.

It is almost absurd to begin to consider the limits of the use of electrical transmission on railways at this date.

The future of electric railways, electric tramways, and automobiles is rather a matter of vague conjecture and picturesque prophecy. Tubes are multiplying rapidly, and railways are putting down electric transmission on suburban lines in Europe and the States. On short lines with many stops we have to contend with inefficiency at starting. On long lines there is difficulty of transmission or cost of transformation and difficulties of collection. We are very much handicapped, or limited, by the want of a suitable variable speed-gear for large powers. For short lines the ordinary tramway system is used and many schemes have been proposed. Three-phase motors, either in cascade with high primary pressures, or arranged simply, are being tried and have many advantages. Various arrangements of motors have also been discussed or tried. Series distribution has been proposed but never tried.

Though it superficially resembles series tramways it differs essentially in the switches being a long way apart, and not worked by the train, and having constant current variable speed generators. One difference makes it practical as far as the switches go, the other efficient. But a variable speed-gear would solve the difficulty very much better than any of these schemes. We could then have simple alternating circuits with all the consequent ease of transmission and transformation, and the trains could go at suitable speeds with high efficiencies throughout. The Leonard is an electrical variable speed-gear, but it is expensive and not very efficient. A few mechanical gears have been proposed to work with synchronous alternating motors. The most obvious arrangement is a system of pumps.

Air pumps with a reservoir have been proposed. A system of oil pumps of variable stroke is also in use to some extent for automobiles. But machinery of that sort practically means that an electromotive must have not only a motor of say 1,000 kw., but what amounts to two sets of motion work. This must mean serious expense. We may therefore say that we are limited by the want of either a variable speed simple alternate-current motor, or a simple variable speed-gear capable of transmitting a very large torque, and packing into an engine. A recently developed scheme is the use of low-frequency alternating currents with laminated series-wound motors. This solves the difficulty, but at the expense of large idle current, induced pressure in short-circuited armature coils, large expensive and inefficient transformers, and the ordinary disadvantages of the series-motor on constant pressure. This plan is well worth serious study.

The collection of large currents at great speeds has long loomed as a limit. The published accounts of experiments at Zossen would lead us to suppose there is no trouble on this score. Still it is a difficulty many engineers fear.

In electric tramways there is no limit in sight. The power can be sent over any distance desired, and there seems to be no limit to the people who want to travel on electrical trams. The question of electrolysis is rather that of a limit to the duration of pipe companies' property. It is a very difficult question. Though the threatened effects of electrolysis have no doubt been exaggerated it is at best a question of degree, and the ingenuity of engineers is continually reducing the chance of damage. [illegible] frequent reversals o[illegible] electrolysis very considerably.

After touching upon various other topics, Mr. Swinburne concluded his able paper with the remark: "I have now tried to bring before you the various barriers which appear to bar our progress in various directions: it is for you to get over those you can, and to get round the rest."

ELECTRIC TRAMWAYS.

At the meeting of the Institution of Civil Engineers, the subject of "Electric Tramways" was dealt with in a paper by Messrs. C. Hopkinson, M.Inst.C.E., B. Hopkinson, and E. Talbot, M.Inst.C.E.

The authors stated that when, about the year [illegible] electric tramways had begun to be constructed in Great Britain on a large scale, there had already been many thousand miles in operation in America, and a vast amount of American experience had been available in connection with this branch of engineering. Consequently, British tramways had been constructed largely according to American methods, and showed a good deal of the uniformity characteristic of American practice. The authors' experience had been gained principally in the construction of the tramway systems of Leeds and Newcastle-on-Tyne, and the paper discussed a number of important points in tramway practice, which were illustrated by reference to these two systems of tramways.

GENERATION OF POWER.

The nature of the load on a tramway generating-station was discussed, and it was shown from actual records to what extent increasing the number of cars resulted in making the load more uniform. With seventy cars or more, the load was so nearly constant that the steam-consumption per unit was substantially the same as though it were constant and equal to the mean. Hence in a station of this size, equalisation of the load by means of a storage-battery was of no use as regarded economy, though in a small station it might be of great value. A storage-battery equal to replacing one-third of the generating-plant for ½-hour, should, however, be installed in a continuous-current power-station for the purpose of replacing a generating unit in case of breakdown, and for running cars at night.

The effect of short circuits on the generators was considered; in the worst case there might be a force equal to three or more times the normal force applied at the periphery of the armature for the period of [illegible] of a second, that being the time which a circuit-breaker took to open. This necessitated a very strong connection between armature and fly-wheel. Another effect of the opening of the circuit-breaker was the sudden diminution of the load on the engine to nothing, which necessitated special arrangements for preventing the engine from running away. This required either very quick governing or a heavy fly-wheel; but, except in the case of short circuits, an ordinary governor and an ordinary fly wheel were sufficient. The question of over-compounding dynamos was considered; and dynamos wound for constant potential were recommended.

TRANSMISSION OF POWER TO THE CARS.

The simplest method of transmitting the power to the [illegible] was to make the trolley-wire into an electrically continuous network and to feed the current into it at various points. In practice, however, it was found necessary to divide the trolley-line into sections insulated from each other, each section being fed at one point. The points of division in the centre of a city were determined by considerations of safety; in the [illegible] districts, questions of economy and the [illegible] of keeping the variations of line-potential within limits might come in. The principles were illustrated by reference to Newcastle-on-Tyne. There was no objection to the line-potential occasionally dropping 100 volts below normal; and this led to the result that a 2½-minute service of cars could be worked up to a distance of 2 miles from a feeding-point. The most economical size of [illegible] was next considered; and it was pointed out that the mean current-density should rarely exceed 300 ampères to the [illegible] [illegible] [illegible] ance of 1 mile or 1½ miles without boosting. The loss in the trolley-wire in supplying ten cars on one [illegible] [illegible] The conclusion was that on the outer sections the line might [illegible] ns 2 miles long.

In many cases excessive traffic on a particular route had [illegible] small on other days. An illustration of this was seen in Leeds recently, wherein fifty cars had to be supplied with current on twenty days in the year at an average distance [illegible] n. The method by which this was done with continuous current and [illegible] found preferable to three-phase high-tension transmi[illegible] [illegible] [illegible] single continuous-current generating-station placed in the centre [illegible]

ROLLING STOCK.

The [illegible] [illegible] [illegible] rapid and well-sustained acceleration, and that [illegible] These requirements could be fulfilled only by motors capable of travelling [illegible] in practice. Curves were given showing the acceleration of the [illegible] various conditions. A mean [illegible] second up to a speed of 10 ft. per second could be obtained with [illegible] in Leeds and Newcastle. The effect of bad driving on starting was considered.

EARTH CURRENTS.

There was much difference of opinion on the subject [illegible] In Great Britain the Board of Trade restriction of the rail-drop to 7 volts had made cases of electrolysis by return currents very rare, but it could not yet be said that absolute safety was secured for metallic [illegible] in the neighbourhood of tramway-tracks. The resistance of the rails and bonds used in tramway practice, as determined in experiments by the authors, was given. In a new fished and bonded joint a good deal of current went through the fish-plates and sole-plates. The Falk cast-welded joint and the thermit-welded joint were described, but it was deemed unadvisable to use such joints on sharp curves or on crossing a bridge with steep [illegible] account of the effect of expansion and contraction. On straight tracks, however, the lateral support to the rails prevented variations of temperature from [illegible] damage.

Experiments were described from which it appeared that from one-sixth to one-fourth of the current in the rails was diverted into the earth. A service of about ten cars per double mile could be worked over a distance of two miles, the feeding-point being at one end, without the seven-volt limit being exceeded.

Where the Board of Trade limit was exceeded, if all the current were taken out of the rails close to the power-station, the extension of the return feeder to points about half-mile distant from the power-station would produce a very marked reduction in the rail-drop, owing to the fact [illegible] current which took place [illegible] with converging routes was thereby avoided. This was the system now adopted in Newcastle-on-Tyne, but provision had been made on the [illegible] ould be divided into two [illegible] each group being run by its own generator. The first comprised all the cars outside a radius of 3 miles, [illegible]

[illegible] current would be taken out of the rails close to the power-station, but a portion [illegible] ient to bring the drop of potential in the rails within the legal limit would be sucked back through a number [illegible] Exceptional [illegible] dealt with by special [illegible] rs and return fe[illegible].

[illegible] that a current of [illegible] amperes in the rails between two points, two miles [illegible] volts between [illegible] tential was proportional to the [illegible] that the con[illegible] the earth was metallic in its nature and not electrolytic to any considerable extent. Examination of the current in the rails [illegible] of the tramway [illegible] amperes passing [illegible] portion of the current [illegible] the gas-pipes. This result was discussed and was shown to be not surprising. The possibility of electrolysis with such currents as did get into the pipes was considered. Unless there were strata of such small extent and high [illegible] ared with the average, and so placed as to cause a concentration of the current into the pipe to a density of a thousand times the mean current-density or more, no corrosion of the pipe would take place, and the 7-volt limit might be exceeded many times without damage to the pipe. On the other hand, if such strata were present, electrolysis (with damage to the pipe) was quite possible, even though the 7-volt limit was not exceeded.

THE BRITISH IRON TRADE.

THERE were some very good things in the paper entitled, "Lessons for the British Iron Trade from American Experience," read by Mr. J. Stephen Jeans, the secretary of the British Iron Trade Association, before the recent meeting of the Staffordshire Iron and Steel Institute.

In his remarks on transport he says :—

AMERICAN TRANSPORTATION.

The history of the American iron trade in the last thirty years is in no small part a history of transportation. The cheap carriage of the ore and coal has been the indispensable condition of the smelting of the one by the other. And, clearly, this factor has not been peculiar to the iron industry. The perfecting of transportation has been almost the most remarkable of the mechanical triumphs of the United States. The efficiency of the railways of the United States has been brought to a point not approached elsewhere, largely in consequence of that very competition whose ill effects have been so often felt. The good has come with the evil ; and here, as in the whole domain of private property and competitive industry, the crucial problem is how to eradicate the ill and yet maintain the good. In the carriage of iron ore and of coal the methods of railway transportation, developed under the stress of eager competition, have been utilised to the utmost ; and the same is true of the transfer from rail to ship and from ship to rail again, of the carriage in the ship itself, and of the handling of accumulated piles of the two materials. The ore is loaded on to cars at the mines by mechanical appliances. At the Mesabi mines the very steam-shovel that digs the ore from the ground deposits it in the adjacent car. In conveying the mineral from the mine to the blast furnaces, hauls of 800, 900, and 1,000 miles are necessary, with two separate breakages of bulk. It has been truly said that fifty years, or even twenty-five years ago, this would have seemed impossible on such a scale, and at so low a cost.

CLEVELAND AND PITTSBURG.

In this country, as we all know, one of the most serious items of manufacturing cost is that of transport, whether for raw materials or for finished products. In the United States, the cost of this item is also very heavy, but not so much because of heavy charges in relation to the distance covered—which appears to be characteristic of British conditions—as because of the enormous distances over which both raw materials and finished products have to be carried. The greatest centre of the British iron industry is the Cleveland district, where the average length of haul for three-fourths of the raw materials used does not exceed twenty miles. The greatest centre of the American iron industry is the Pittsburg district, where the average haul of the raw materials used is not much under 600 miles, taking the average of Lake Superior ore at 1,000 miles, and the average of coke, limestone, etc., at 40 to 50 miles. In the Cleveland district the total transportation costs of the home raw materials used per ton of pig iron produced may be taken as 8s. 6d. to 10s., including ore, fuel, and flux. In the Pittsburg district the corresponding total cost may be taken at 12s. for iron ores, 3s. to 4s. for coke, and 1s. 6d. for limestone, etc., per ton of pig iron produced, making up a total of about 18s. per ton of iron, or fully 8s. 6d. per ton more than the average of the Cleveland district. These costs vary from period to period according to the conditions and the demand.

THE SOUTH STAFFORDSHIRE DISTRICT.

In many other districts the costs of transport per ton of pig iron generally take a higher range than those of Cleveland, except at a few of the Scotch works where the local ore is still used, and in which the coal and the ironstone are practically mined on the spot. Nevertheless, the distances to be covered are not in any case what would be considered excessive, but rather the contrary, in any other country except our own. It is probable that the district of South Staffordshire labours under greater disadvantages than any other, since the local supplies of iron ore are limited, and by no means cheap, while the markets for a large part of the finished products, though geographically close at hand, are, in point of cost, a long way off. There is no important centre of the American iron industry that would not be regarded as admirably situated for foreign trade if located as near to the sea as this district. No such good fortune attends the American iron trade. Even in the neighbourhood of Philadelphia the ironworks are over a hundred miles from the ocean, while in Pittsburg they are nearly 500 miles, in Chicago nearly 1,000 miles, and in Cleveland, Ohio, and Youngstown (Ohio), they are 600 to 700 miles. Hence, although you are accustomed to think of yourselves as worse off in this respect than most competitive districts, you are well within a hundred miles, or but little more than one-third, of the distance of the most favourably situated of the iron centres of the Southern States, and less than one-fifth of the distance of the furnaces of Pittsburg.

THE QUESTION OF THE FUTURE CHEAP TRANSPORT.

To those who are engaged in the heavy trade of this country, the greatest question of the day, and of the future, is that of cheap transportation. With cheap transport, you could bring both ores and fuel to this district from within a much wider area than now, while you could also introduce, where expedient, the cheap products of other countries, enabling you to utilise semi-finished steel, in the form of blooms and billets, as furnished by

Germany and the United States, to produce the finished forms of manufacture that are disposed of both in our home and foreign markets.

In order to enable me to place before you some idea of the difference in American and British conditions of transport, I have obtained through my friend, Mr. T. N. Eley, Chief Mechanical Engineer of the Pennsylvania Railroad Company, the annual report of that great corporation for the year 1901. This report shows that the average length of haul for all descriptions of traffic, mineral included, was in that year 104½ miles, or about 8½ miles less than the distance by the London and North Western Railway from Birmingham to London, and about 16½ miles less than the distance from Dudley to London. The members of the Institute will be perfectly familiar with the charges made for transport from here to the Thames, or other shipping centres. The Pennsylvania average earnings per ton carried over the distance of 104½ miles—including all sorts of freight—were only [illegible] 2s. 6d., which corresponds to ·26d. per ton-mile. The average cost of the service is given at ·19d. per ton-mile, so that the average profit per ton-mile was only ·10d., or about 38 per cent. This, so far as the Pennsylvania Company is concerned, is all that is left to pay working expenses, interest on capital, repairs and renewals, and everything else that has to come against goods and mineral traffic.

300 PER CENT. PROFIT.

Now let me compare this situation with that of British railway transport. We have here no authoritative record of the cost of working railway traffic. When the Railway and Canal Traffic Bill was before the Board of Trade, I [illegible] in the course of cross-examination of the late Sir George Findlay, the then General Manager of the London and North Western Railway, that the cost of conveying a ton of mineral was about one farthing per mile. The average receipts per ton-mile was then unascertainable. But it has since been given by Mr. G. Gibb, the General Manager of the North-Eastern Railway, at a trifle over [illegible] virtually a penny—for mineral traffic, from which it is to be inferred that instead of being satisfied with a profit of 38 per cent. the British Railways charge a profit of about 300 per cent. I think this [illegible] is all the more justified, because I happen to know that the North-Eastern Railway Company is by no means one of the worst offenders in the matter of high charges.

We have seen that the average working cost per ton-mile of the Pennsylvania Railroad traffic is ·19d. Is this very much below the British average, and, if so, why so? I do not doubt that this is a considerably lower figure than British railway working costs can be expected to reach. The average haul on American lines is probably three times that of our own. In 1901 the average number of tons in a Pennsylvania loaded car was about 21 (exactly 20·83), and the average train load was 480 tons, or probably three times the average of British lines. All this helps a low cost of transport. British railways will never enjoy an average haul of over 100 miles, and their gradients being what they are, it is doubtful whether they will ever have an average train load of about 500 tons all round.

HIGH-SPEED ELECTRICAL GENERATING PLANT.

At a meeting of the Institution of Civil Engineers, Mr. John Clarke Hawkshaw, M.A., President, in the chair, a paper on "High-Speed Electrical Generating Plant" was contributed by Mr. T. H. Minshall.

The paper had been written with the object of comparing the relative advantages of high and low-speed combinations for the purpose of generating electricity, a subject of growing importance in view of the large number of power stations now being erected.

The author considered (1) the relative adaptability of the two types, (2) their relative efficiency, (3) the cost of maintenance.

Finally, the author considered the capital cost and the bearing which the load-factor had upon the latter. A table was included giving the estimated cost of four power-houses, two with high-speed and two with low-speed machinery. The probable cost of production per Board of Trade unit generated with different prices of fuel and different load-factors was given, from which it was shown that the load-factor was by far the most important element in the determination of the type of machinery to be used.

The paper ended with a short summary of the conclusions arrived at, it being shown that although the low-speed combination at full load had a somewhat lower steam consumption, it was not always sufficient to outweigh the higher capital cost.

THE OCCURRENCE OF ASBESTOS IN THE N.W. PROVINCES OF INDIA.

The following note on the occurrence of Asbestos in the N.W. Provinces of India was recently read by Mr. F. J. Stephens, before the Institution of Mining and Metallurgy:—

Asbestos is known to occur in three localities in the N.W. Provinces of India, viz., Pithagora in Kumaon, on Badhangurh Mountain, and near Joshimath in Garlwal.

At Pithagora, an impure serpentine, when traversed by a greenish translucent jade, is found to contain innumerable little veins of greenish and white asbestos, rarely more than ¼ in. in width.

Badhangurh Mountain rises to a height of 9,500 ft. in the dividing range between Kumaon and Garlwal. Hornblende rock, forming part of the mountain, is traversed by parallel veins of white, silky asbestos, sometimes 6 in. wide.

The third locality is about 70 miles from the town of Raniklet, in Kumaon, and close to the Mana and Niti passes into Thibet. Veins of asbestos, sometimes 4 or 5 in. in width, and masses of asbestos, sometimes more than 6 ft. in width, occur in a rock of serpentinous nature.

NEW AUTOMATIC COUPLER

A MEETING of the Institution of Junior Engineers was recently devoted to the consideration of "A New Automatic Railway Coupling, Compared with the Existing System upon the British Railways," by Mr. A. T. Swaine, A.M.I.Mech.E.

Called for convenience by its initial letters the A. B. C. system, the new Automatic Buffer Coupler was stated to be an exceedingly simple and ingenious piece of mechanism, consisting of three parts only, which are precisely alike on both ends of the buffer waggons. To ensure economy in manufacture, it has been designed with the special object of rendering machining practically unnecessary, and it was remarked that it is capable of working with the existing side-buffer system during the transition stage.

It was stated that the present design of waggon frame is very suitable for the adoption of the new type of coupler with a continuous drawgear, ensuring longer life for the waggon, and less cost for repairs. The author claimed that the conversion could be effected without a large demand upon capital, and estimated that on account of the reduced weight of the new gear and other reasons, the advantages of its adoption on British railways would represent about 7½ millions sterling per annum.

COMING EVENTS: JANUARY, 1903.

1st.—Civil and Mechanical Engineers' Society: Paper—"Indicating High Speed Engines," by Mr. A. Marshall-Arter, A.M.Inst.C.E., Caxton Hall, Caxton Street, Westminster, at 8 p.m.

2nd.—Institution of Junior Engineers: Paper—"Marine Boilers: a Consideration of the Relative Values of Different Types," by Mr. H. M. Routhwaite, M.I.M.E., Westminster Palace Hotel, Victoria St., S.W., at 8 p.m.

3rd.—Birmingham Association of Mechanical Engineers: Inaugural Address and Half-Yearly Balance Sheet, Grand Hotel, Colmore Row.

5th.—Institute of Marine Engineers meets.

8th.—Institution of Electrical Engineers, Great George Street, Westminster, at 8 p.m.

10th.—Birmingham Association of Mechanical Engineers, Grand Hotel, Colmore Row.—Glasgow Technical College and Scientific Society: Paper—"Recent Developments in the Gas Engine and the Utilisation of Blast Furnace Gases, by Prof. T. Hudson Beare.

12th.—Institution of Mechanical Engineers: Graduates, Meeting at 7.30 p.m.—Institute of Marine Engineers meets—North-East Coast Institution of Engineers and Shipbuilders: Council Meeting at Newcastle-upon-Tyne.

13th.—Institution of Civil Engineers: Ordinary Meeting at 8 p.m.

14th.—Liverpool Engineering Society: Paper—"The Use and Abuse of Engineering Education," by Mr. A. F. Fowler, M.Inst.C.E., M.I.Mech.E.

15th.—Institution of Mining and Metallurgy meets.

16th.—Institution of Mechanical Engineers: Nomination for Annual Election of Officers, 8 p.m.—Institution of Civil Engineers: Students' Meetings at 8 p.m.

17th.—Manchester Association of Engineers: President's Inaugural Address, "Masonic Room," Grand Hotel, Aytoun Street, at 7 p.m.—North-East Coast Institution of Engineers and Shipbuilders: Graduates Meeting at Newcastle-upon-Tyne.—The Staffordshire Iron and Steel Institute: Paper—"The Utilisation of Our Tips for the Production of Pit Timber," by Mr. Herbert Stone, F.L.S.

19th.—Institute of Marine Engineers meets.

20th.—Institution of Civil Engineers: Ordinary Meeting at 8 p.m.

22nd.—Institution of Electrical Engineers, Great George Street, Westminster.

23rd.—North-East Coast Institution of Engineers and Shipbuilders: General Meeting, Newcastle-upon-Tyne. Paper—"Minimum Metacentric Heights in Small Vessels," by Mr. Joseph H. Pescod.

26th.—Institute of Marine Engineers meets.

27th.—Institution of Civil Engineers: Ordinary Meeting at 8 p.m.

28th.—Liverpool Engineering Society meets: Paper—"Expert Evidence," by Mr. E. W. Pierce (Deputy Town Clerk).

30th.—Institution of Civil Engineers: Students' Meeting at 8 p.m.

31st.—Manchester Association of Engineers: Paper by Mr. R. M. Neilson, Manchester, "Steam Turbines," "Masonic" Room, Grand Hotel, Aytoun Street, at 7 p.m.—North of England Institute of Mining and Mechanical Engineers: Council Meeting at 1.30 p.m.

REVIEW OF LEADING CONTINENTAL PAPERS.

A Monthly Review of the leading papers read before the various Engineering Technical Institutions of the Continent.

BELLEVILLE BOILERS FIRED BY THE WASTE HEAT OF COKE-OVENS.

THE plant laid down at the suggestion of M. Thorez, managing director of the Compagnie des Mines d'Azincourt et des Fours à Coke du Nord, and which forms the subject of a communication by M. Jules Quoirez to the *Society of Hainaut Engineers*, comprises four C 8 boilers (*i.e.*, each comprising eight elements, and each element being formed of sixteen tubes), the heating surface of each boiler being 132 sq. m. (159 square yards), and the licensed pressure 15 kg. per sq. cm. (213 lb. per square inch). The boilers are fired by the waste heat of 40 Belgian coke-ovens, coking in forty-eight hours.

On each side of the centre line is a bank of twenty ovens with two boilers, while the flame collectors of the two groups are prolonged and connected together, the boilers being put up directly on the portion of collector between the two groups. Behind the boilers is a general flue, which leads the gases to the chimney, after passing through the boilers ; and a branch from the main flue permits of sending the flames directly up the chimney if desired. The flames are directed in such a manner, that thanks to a series of vertical registers, it is possible to (1) work with four boilers ; (2) work without the boilers ; (3) throw out one or more boilers and work with the others ; or (4) utilise the flames of one group of ovens for the boilers, and send the flames of the other group directly up the chimney, a change from one to another of these various combinations, necessary for cleaning and repairs, involving no stoppage.

Vaporisation tests were made first on three and afterwards on four boilers, three being generally in action while a fourth is thrown out. The boilers were fed automatically with purified water ; and during the tests the pressure was maintained at 12·5 kg. per sq. cm. (177 lb. per square inch). The tests began at 6 a.m., the hour the charges are drawn, and lasted until the same hour on the following day, thus making twenty-four hours.

The results obtained with four boilers were better than those with three; but they are not proportional to the increased heating surface. This proves that three C 8 boilers are sufficient for forty ovens ; but four are necessary for always having one out. In designing a plant, therefore, a total heating surface of 528÷40=13 sq. m. (15 square yards) must be allowed per furnace, although 10 sq. m. (12 square yards are sufficient in regular working).

Calculation shews a daily saving of nineteen tons ; but in reality the consumption was reduced from 20·4 to 8·8, giving an economy of 11·6 tons daily. This constitutes 60 per cent. of the theoretical saving, the balance being attributed to various losses, viz., (1) the inevitable condensation in a steam pipe about 300 m. (328 yards) long, (2) radiation and (3) escape into the air of a certain quantity of steam when the engines are stopped, a loss which appears inevitable in such an installation.

COAL WASHING—THE COPPÉE WASHER.

IN consequence of several discussions with mining engineers, chiefly in the North of France, who criticised the old mode of coal washing, and strongly advocated the new methods employed in Germany, M. Léon Moulan, head draughtsman of the Maison Evence Coppée, Brussels, decided to visit the new washing plants in Westphalia, and recorded the results of his observations to the *Société des Ingénieurs d'Industrie et des Mines du Hainaut.* He set himself the task of describing the methods of treating various coals as regards the wash-water *régime*, with recovery of the schlamms, or slurry; and he asserts that all the present arrangements of washing-floor are good, but that a method of washing applicable in one case will not necessarily give good results in another.

M. Moulan visited the Baum washery at the Dahlbusch Colliery, capable of treating eighty tons of unscreened coal per hour, the Humboldt plant at the Scharnhorst Colliery, making four sizes, and the Schuchterman und Kremern washing floor at the Burbach Colliery, where the schlamms are treated by shaking sieves on the Von Staszewski system. He remarks that the plants described are quite simple, and the programmes which served for their design were well determined, the object being to simply wash everything up to a 10 mm. ($\frac{7}{16}$ in.) gauge for coke-making.

The problem, however, becomes complicated in the case of dusty coal, because it is necessary to separate the 2 to 3 millimetres dust, which has to be washed or not, according to the coke it may be desired to obtain, so that means must be provided for reconstituting the washed coal of 2 to 9 millimetres gauge with the dust not washed. In the

COPPÉE WASHERY,

designed to meet this requirement, the raw coal is raised by a bucket-chain to balanced screens, which class the coal by separating the largest size, to finish by the finest, which is dust; and this dust either falls into a tower when not washed, or is led to the washer intended for it when washing is found necessary. Of the other classes, the 2½ to 5½ and 5½ to 10 millimetres, are treated in felspar boxes, and the 10 to 18, 18 to 25, and 25 to 45 millimetres (25 mm.=1 in.) in "grain boxes." The 18 to 45 mm. sizes constitute the "grains" of commerce, being stored in towers after having previously drained on fixed or movable screens.

The washed coals from 2½ to 10 millimetres gauge, constituting the "washed fine," are drained in towers, after which revolving sole plates permit of reconstituting 0 to 10 mm. slack, of various proportions as regards size for a given ash content. This mixture, to which washed grains of 10 to 18 mm. gauge may be added, if necessary, is wholly or partially led by a transporter to crushing rolls; and, after crushing, it is raised by a bucket-chain to towers connected with the coke-ovens by a foot-bridge. The shales of all the washers are led into a pit, whence a bucket-chain takes them up to a storing tower.

The washery basement of 160 sq. m. (180 square yards) surface, constitutes—(1) the shale basin, (2) the "washed fine" basin, and (3) the decantation basin of the schlamms. From this last-named basin a bucket-chain takes up the schlamms for mixing them with the "washed fine" coals; but the schlamms may be separated from the washed coal if their ash content is too high, in which case the schlamms would constitute a distinct product that might be used for firing boilers or sold as inferior fuel.

With coal of 0 to 50 mm. (2in.) gauge, containing 26 per cent. of ash, the following products have been obtained at the Ressaix Colliery, Belgium—coking slack, composed of a mixture of 2 to 9 millimetres washed coal and unwashed dust, showing from 9 to 10 per cent. of ash; washed grains of 5 to 6 per cent. ash content, with 13 per cent. of loss in shale, and 7 per cent. of inferior products containing 25 per cent. of ash.

What specially characterises this washing plant, is that the taking up of the schlamm by a bucket-chain permits of making it a special product when necessary, so as not to increase the ash content of the washed coal.

COMPARATIVE EFFICIENCY OF GAS AND STEAM ENGINES.

IT is not so very long ago that steam had an easy victory over gas, while only small gas engines were available; but now the matter is very different. The power of gas engines has increased from 8, 10 and 20 h.p. to 50, 100, 500, and even more than 1,000 h.p., while the gas consumption has diminished by one half, being currently about 500 litres (17·6 cubic feet) per h.p. per hour, and sometimes less. This result is due to the increase of previous compression, expansion, and speed ; a better mingling of the gas with the air necessary for combustion ; a better regulated ignition, giving fewer misses, and a more rational construction, all these concurring to give the gas engine better thermic and organic yields.

Moreover, the use of gas-producers, permitting the practical and economical manufacture of poor gas, and their improvement, so as to burn ordinary non-bituminous coal, brought down the cost of gas. Accordingly, the gas motor has in turn beaten the steam engine, especially since Mond producers have permitted the use of cheap bituminous slack, and of recovering the valuable ammoniacal products. The above comments are taken from a paper contributed by M. Auguste Moreau to the *Société des Ingénieurs Civils de France.*

STEAM BOILER.

Trials of good boilers, put up under the best conditions, have shown a useful effect of 70·8 to 75·5 per cent. ; but for such a result active and skilful stokers are required, as negligent or incapable men may increase the cost by 10 to 15 per cent. Again, if some boilers can show a useful effect of 77·5 per cent. during trials, this maximum is rarely attained ; and a yield of 70 per cent. is considered satisfactory, while no more than a mean of 60 per cent. can be relied upon throughout the year.

STEAM ENGINE.

With the best arrangement of engine, and under the most favourable conditions, a thermic yield of 18·8 per cent. obtained by Professor Thurston appears to be a maximum, that can only be brought up to 19 per cent. by superheating the steam. In ordinary practice 17 per cent. is rarely exceeded.

ENGINE AND BOILER.

In accordance with the preceding figures the grouping of engine and boiler, each supposed to be the best of its kind, and working under the most favourable conditions, with superheating of the steam by the waste heat of the furnace, gives an indicated yield of $775 \times 0{\cdot}19 = 0{\cdot}147$; but even 0·14 (to allow for loss in leading the steam from the boiler to the cylinder) is far from being obtained in current practice.

GAS PRODUCER.

Besides the reaction $C + HO = CO + H$, there is combustion of a portion of the coal, the whole operation producing a poor gas, which has only one-fourth the calorific power of ordinary lighting gas, so that, for exerting the same effect, four times more poor gas is required, the presence of inert gas in the cylinder reducing the power of the motor by about one-fifth, which, however, can be counteracted by increasing the compression. According to Professor Witz, the useful gases represent about half the total volume ; and with coal at 25 francs (20s.) per ton, the cost of poor gas, including interest, sinking fund and various expenses, comes out at 0·015 franc per cubic metre (about 5d. per 1,000 cubic feet.)

The thermic yield of gas producers, like that of boilers, is subject to great variation according to the nature of the fuel, the working of the fire, which is regulated by the proportion of steam injected (which again is dependent on the quantity of air and quality of the coal), the volume of the gas, its degree of purification, etc. The gas volume is, in fact, far from being constant ; and this leads to appreciable differences in the quality of the gas and the phenomena of the reductions. Impartial trials have shown that the yield of a producer, tested with the usual precautions, varies from 80 to 84 per cent., and that from 62 to 63 per cent. may be relied upon in ordinary practice.

GAS ENGINE.

The gas motor shows its best thermic yields from 10 h.p. upwards, being equally suitable for the use of service gas as that of poor gas, while the same may now be said of blast-furnace gas with very low calorific capacity. Numerous trials have shown that yields of 31·6 per cent. indicated, and 27 per cent. effective, can easily be obtained.

GAS PRODUCER AND ENGINE.

Accordingly, a gas engine of the efficiency just named, together with a producer of 84 per cent. yield, give an ultimate useful effect of $0{\cdot}84 \times 0{\cdot}316 = 0{\cdot}2654$ indicated, or $0{\cdot}84 \times 0{\cdot}27 = 0{\cdot}2268$ effective, which figures, however, are rarely attained in practice, producer and motor with the maximum yield being seldom combined, while losses occur in the passage from one to another.

CONCLUSION.

The thermic yield of the gas producer is, therefore, a little higher than that of the steam boiler; the efficiency of the gas engine is considerably superior to that of the best steam engine, and the fuel consumption with the simplest gas group is far from attaining that of the most important steam group, thus giving a definite victory to gas.

PHYSICAL PROPERTIES OF NICKEL STEEL.

THE late Dr. John Hopkinson made the very unexpected discovery that an alloy of steel with 25 per cent. nickel (which alloy is not magnetic, although its component parts are strongly magnetic), subjected to a very low temperature, becomes magnetic, and preserves its new state indefinitely when brought back to the ordinary temperature, losing it only when raised to a red heat; and M. Charles Edouard Guillaume, of the International Weights and Measures Bureau, was the first to point out that there are two very distinct categories of nickel steels, viz., the reversible and the non-reversible. These and other peculiarities of steel and nickel alloys were dealt with in a paper by M. Paillot to the *Société Industrielle du Nord de la France*, of which the following is an abstract.

REVERSIBLE ALLOYS.

These alloys, which generally contain more than 25 per cent. of nickel, gradually lose their magnetic properties when heated, but re-acquire them on cooling; and their magnetic properties are only a function of the temperature. The transformation temperature, *i.e.*, that at which the alloy becomes non-magnetic, rises with the nickel content; and for contents little higher than 25 per cent., the alloy is only magnetic at temperatures below zero Centigrade (32 deg. F.).

NON-REVERSIBLE ALLOYS,

which generally contain less than 25 per cent. of nickel are, in a certain state, strongly magnetic; but they gradually lose their magnetic properties between temperatures corresponding with dark red and cherry red, only resuming them by cooling, at a temperature so much lower as they contain more nickel; and for alloys with nickel content near upon 25; this temperature is less than zero Centigrade. The non-reversible alloys harden on passing into the magnetic state, while they are malleable, so that there is great practical advantage in delaying their transformation in order to ensure, under all circumstances, that malleability for which they are so much prized. This object is attained for the first time by adding from 2 to 3 per cent. of chrome to alloys containing a little less than 25 per cent. of nickel, such alloys remaining non-magnetic even at the temperature of liquid air.

M. Osmond has shown that manganese or carbon exert similar effects; and the experiments of M. L. Dumas have chiefly brought out the fact that alloys may belong to the reversible or non-reversible category, not only through their nickel content, but also owing to the action of chrome, carbon, or manganese, which elements lower the transformation point so as to bring it below zero Centigrade for nickel contents, in which it may be near upon 600 deg. Centigrade forn early pure ferro-nickel. Passage of the non-reversible alloys to the magnetic state may be provoked, not only by the action of cold, but also by any mechanical operation, such as cold forging, turning and wire-drawing.

CHANGES OF VOLUME.

Dr. Hopkinson was the first to find that a sample of ferro-nickel had diminished in density by about 2 per cent. through passing into the magnetic state, and M. Benoît showed that a non-magnetic alloy containing 22 per cent. of nickel and 2 per cent. of chrome expands almost in the same ratio as brass, while M. Le Chatelier found that the non-reversible alloys are far more dilatable in the non-magnetic than in the magnetic state. M. Guillaume, who has profoundly studied the dilatation of nickel steels, has noticed that, while the non-reversible alloys gradually resume their magnetism on cooling, they also increase in volume and in a non-reversible manner.

The transformation of non-reversible steels is gradual for the dilatation as it is for the magnetism, while one and the same alloy may have a given dilatation between two determined limits according to its degree of transformation; and at one of the extreme states the dilatation is but little greater than that of brass, although at the other state it may be less than that of ordinary steels. At the usual temperature the reversible steels have a dilatation which varies continually with the content, being a little greater than that of nickel for slight contents, diminishing gradually when the content increases, passing through a maximum, and then again rising. Steels containing from 35 to 36 per cent. of nickel dilate ten times less than does platinum. Accordingly, there exist two alloys, one near upon the least dilatable, and the other, containing about 45 per cent. of nickel, for which the dilatation is constant between wide limits of temperature; and chrome increases the dilatation, as also does manganese.

MECHANICAL PROPERTIES.

Non-reversible alloys are far harder and less subject to deformation in the magnetic than in the non-magnetic state; and the limit of permanent deformation is also far higher in the former than in the latter. Wires made of steel containing 24 per cent. of nickel resemble well-annealed brass wires when in the non-magnetic state, whereas in the magnetic state they afford springs like those of hardened steel. Density increases with the nickel content; in samples with 26 to 40 per cent. of nickel the densities are all comprised between 8 and 8·1, most of them being higher than 8·05.

It is a remarkable fact that thoroughly homogeneous and perfectly elastic alloys of iron and nickel have a modulus of elasticity which is lower by more than one-third than that of the mean of the two metals composing it.

GOLD IN TURKESTAN AND BOKHARA.

NEXT year will be marked by a great event in the history of Far East railways, for it is then that the line is to be opened connecting Oxenbourg with Tachkent, the capital of Bokhara, and traversing in a straight line of 2,300 km. (1,429 miles) the immense salt plains formerly occupied by the Sea of Aral. The great rapidity with which this work, begun in 1901, has been carried on is in a great measure due to the fact that the only difficulties encountered have been the traversing and consolidation of the sand and the deficiency of water.

These observations are made in a paper to the *Société des Ingénieurs Civils de France* by M. E. D. Levat, who was charged by the French Minister of Public Instruction with a mission, the chief object of which was to study the geological and mining conditions of Bokhara and Turkestan. For 1902, however, he was obliged to limit his examination to a study of the coal and petroleum deposits and the gold-bearing placers, which present the most immediate interest—the gold because it is the only metal which, susceptible of being worked at great distances from means of communication, lends itself to a remunerative industry.

AURIFEROUS DEPOSITS.

Investigation in this department bore entirely upon the alluvial deposits, *i.e.*, those in which gold is met with in the native state, in grains and nuggets, mixed with detritus from water action or of glacial origin; and it is by a combination of these two agencies (remarks M. Levat) that have been formed the thick beds of gold-bearing conglomerate in Eastern Bokhara on the western slope of the Darvaz chain. Auriferous deposits on the spot where they were formed, consisting of veins, masses or beds, have, however, been found in the Pamir; but they are not yet worked. Conformably with the usual practice, it is by the alluviums that should begin all gold mining in a new country; and the veins afterwards continue the industry in a region thus opened up to civilisation, while the placers serve as a connecting link.

On 20th June last the Mission attained the Mazar-Sou zone of gold-bearing conglomerates, which comprises all the upper valley of the Obi-Sanghi-Khergov, and extends towards the north-east to a direct tributary of the Khingaou, all these water-courses being auriferous. The Mission then passed into the basin of the Yak-Sou, and made its way up this stream, by

Saripoul and Talbar, and examined the workings of the Sarthian gold-washers both open-cast and underground, the latter being well worthy of notice, as they reveal thorough knowledge as to enrichment of the gravels with depth. These workings were, therefore, of great service in determining the gold content of the auriferous alluvia in depth, thus saving the necessity for sinking fresh shafts.

It is, in fact, below the present level of the rivers that occur the gold-bearing deposits of real value, because all above this level, which could be easily got at by the natives, have already been worked several times, so that there is nothing left for modern industry even with improved plant. It will be remembered that the Sarthians were preceded by the Mongolians, whose influence on the methods of extraction employed by their successors is evident to those acquainted with Chinese and Korean methods of gold mining.

The Mission also visited the workings undertaken in the valley of the Safet-Daria by Engineer Pakorski. Although they have not reached the bed rock, the richest portion of the deposit, they sufficiently confirm what the Sarthian workings had already indicated, viz., that the auriferous deposits of Eastern Bokhara are constituted by very thick beds of gold-bearing gravels, the richness of which, generally slight at the surface, attains its maximum on contact with the bed-rock.

In the Amu-Daria the Sarthians wash gold in the sand of the river, much lower than Sarai; and the author found, in the surface sands of the water-courses at Sarai, Dagana and Saripoul, gold contents which justify every expectation, as regards the richness that may be met with in depth. These last-named deposits, however, far distant from mountains the torrents of which might afford water power—the only one at present available—can but be regarded as reserves for the future, when means of communication may be afforded.

As regards the manual working of these alluvia by Siberian methods, with pickaxe and rustic carts, carrying out the waste to spoil, it appears to the author that, except in unusual instances, there is no profit to be looked for, as the quantities to be moved and washed are too great for primitive methods. On the contrary, working must only be attempted by powerful plant, dredges or excavators, with mechanical transport of the spoil, as now practised in most of the large placers in America and even Siberia.

Such action would cope with the exigencies of Sarthian labour, which is now, however, cheap, viz., 1½ to 2 tenguis (from 6d. to 8d.) per day; but prices would soon rise with a little demand, while Sarthian labour is not of that quality which can be regarded as suitable for industrial operations. The chief difficulty would be that of transport, as there is not a single practicable road in the whole of Eastern Bokhara.

SOME BOOKS OF THE MONTH.

"A NEW SYSTEM OF HEAVY GOODS TRANSPORT ON COMMON ROADS."

By Bramah Joseph Diplock. Longmans, Green and Co. 116 pp. Price 6s. 6d.

MR. DIPLOCK describes a new traction engine which he has invented. Some years ago, having occasion to superintend a large amount of exceptionally difficult traction engine work over rough surfaces, he became impressed with the failings of the ordinary road locomotive, and determined to invent a better system of transport on common roads. In 1893, he took out a patent for an engine to drive and steer all four wheels. The gear wheels on the road axles are mounted on the *centres* of the axles, with a special form of universal joint inside the gear-wheels, which not only admits of *both* axles being steered for turning corners, without disturbing the line of the engine, but the same arrangement allows the axles to oscillate horizontally to an almost unlimited extent.

This invention, which is termed "No. 1 Engine," was supplemented by a second, conceived on more novel lines. The feature which characterises the "pedrail," as the author describes "No. 2 Engine," is the curious formation of the front wheels. The pedrail system places feet on the ground, each foot supporting a roller on edge, and a short rail, supporting the load, is levered along by the spokes over the rollers. In the interesting photograph of this engine, which represents the pedrail surmounting a formidable pile of bricks, the front wheels are seen to be fitted with sixteen round feet, which come in contact with the surface of the road three at a time as the wheel revolves. Each foot is attached to the end of a sliding spoke, and pivoted by a ball-and-socket joint, so that it can turn to any reasonable angle, to suit the surface of the road.

Professor Hele Shaw has reported favourably on the new method of traction, and thinks it has a great future before it, as the solution of one of the greatest difficulties which will be met with in developing self-propelled traffic. The "pedrail" has an i.h.p. of 108, and can draw a train of trucks having pedrail wheels, and weighing 150 to 200 tons, at a speed of four to five miles an hour on the level, when fitted with high-speed gearing. The normal speed is about three miles an hour.

Mr. Diplock's description of his invention is clearly written, and the arguments in favour of his system are very lucidly put. He looks forward to establishing an extensive system of goods traffic throughout the country, and his ideas have already reached the limited liability company stage.

"AN ELEMENTARY MANUAL ON STEAM AND THE STEAM ENGINE."

By Andrew Jamieson, M.Inst.C.E. Charles Griffin and Co., Ltd. 327 pp. 3s. 6d.

A COMPANION book to Mr. Jamieson's "Elementary Applied Mechanics," this useful handbook now appears in its ninth edition, revised and enlarged. It is intended for the study of apprentice engineers and elementary students, and consists of twenty-eight short lectures, to which have been added, in this edition, all the most important elementary questions set at the May examinations of the Board of Education and of the Science and Art Department for the past twelve years. The 1902 Elementary Steam Examination has been specially printed at the end of the book, along with general instructions, as an example for teachers and students. Up-to-date information has also been provided concerning thermo-electric pyrometers, the latest type of steam engine indicator, and the machinery employed at the new tramway power-stations of the London County Council and the Glasgow Corporation. An interesting feature is an account of the Hon. C. G. Parsons' steam turbine, illustrated by five views.

"MECHANICS, THEORETICAL, APPLIED, AND EXPERIMENTAL."

By W. W. F. Pullen, Wh.Sc., M.I.M.E., A.M.I.C.E. Longmans, Green and Co. 379 pp. 4s. 6d.

MR. PULLEN'S new text-book is intended for the use of elementary students, and aims at leading them by easy stages from the known to the unknown. It includes a discussion of the principles of the subject (commonly known as theoretical mechanics), descriptions and instructions for experiments in the laboratory, and the application of the principles to the solution of easy problems of a more or less technical nature (generally known as applied mechanics). The work has been to some extent simplified by avoiding the introduction of mixed mathematics. No pains have been spared to make the principles involved as clear as possible to the student, and numerous examples and diagrams have been introduced with this object.

"DESIGNING IRONWORK."

Second Series. Part III.: Cisterns and Tanks. By Henry Adams, Professor of Engineering. Paper covers. Published by the Author at 60, Queen Victoria Street, London, E.C. 48 pp. 2s.

THE subject upon which the author treats cannot fail to be of special interest to the constructional engineer and the architect. In this volume notes are given upon cisterns and tanks in general, together with detail drawings and calculations for a cast-iron tank to contain 15,000 gallons. Professor Adams's facts are given in a clear and concise manner, and, in view of the fact that there is so little information available upon this subject in existing text-books, his work should prove of the greatest assistance to practical men.

"PRACTICAL ELECTRICITY."

By J. Hope Belcher, B.A., B.Sc., F.C.S. Allman and Son, Ltd. 165 pp. 2s. 6d.

AN elementary text-book suitable for use in schools. It provides a series of well-selected exercises, demonstrating the application of the first principles of the science and illustrating the use of simple apparatus.

"DIFFERENTIAL CALCULUS FOR BEGINNERS."

By Alfred Lodge, M.A. George Bell and Sons. 278 pp.

THE object of this book is to provide an easy introduction to the calculus for those students who have to use it in their practical work and to make them familiar with its ideas and methods within a limited range. Stress is laid at the outset on the graphic representation of functions, as by this means a vividness and reality is given to the processes of the calculus which is not easily obtained without such ocular assistance. Numerous illustrative examples will be found throughout the book, some of which are of intrinsic importance, while others are intended to prepare the student for future developments. In a lucid introduction to the volume, the author's brother, Sir Oliver Lodge, describes the range of studies which are open to the student who has a fair working acquaintance with the calculus.

"ELEMENTARY MANUAL ON APPLIED MECHANICS."

By Andrew Jamieson, M.Inst.C.E. Chas. Griffin and Co., Ltd. 345 pp. 3s. 6d.

THIS useful text-book now appears in its fifth edition, revised and enlarged. The course of study is specially adapted for the use of first year Board of Education, South Kensington, City and Guilds of London Institute, Colonial and other engineering students. The book is divided into four stages, embracing the study of forces in equilibrium and the principle of moments and of work as applied to simple machines, hydraulics, the laws of motion, and the properties and strength of materials. These sections are dealt with in twenty-four lectures. To the new edition have been added short descriptions with illustrations of the best forms of limit and micrometer gauges, together with the questions of the Science and Art Examinations for the past twelve years. There is a wealth of illustrations and descriptive matter, and a quantity of useful information is contained in the appendices.

"ENGINEERING ARITHMETIC AND MENSURATION."

By Charles R. Honiball, M.I.Mech.E. Mackie and Co., Ltd. 553 pp. 4s. 6d. net

THE above work, which has now run into its third edition, provides a simple application of the ordinary rules of arithmetic and mensuration to elementary problems met with in the workshop. The writer, who has had experience in both the workshop and the lecture room, gives, in a plain and terse manner, without needless prolixity, a practical elucidation of the main principles of arithmetic and mensuration. To the young engineering student or mechanic, who is undergoing his course of workshop instruction, the work especially commends itself, as in it he will find exercises in many of the problems he encounters in every-day experiences. The present edition contains several new examination papers. Upwards of 1,500 problems are given, with answers, and the methods of working are clearly described.

CATALOGUES AND TRADE PUBLICATIONS.

These catalogues may be had free of charge on application to the firms issuing them. Please mention PAGE'S MAGAZINE when you write. Manufacturers of Engineering and Electrical Specialities, etc., etc., are invited to forward, for review in this column, copies of their catalogues, price lists, and circulars, as soon as issued.

Lancaster and Tonge, Limited, Pendleton, Manchester.—A catalogue of unique and original design, the cover looking very much like a slate in wooden frame, on which appears (in characters representing the writing from an ordinary slate pencil) a short notice of the "Lancaster" specialities. Between the covers are sixteen pages of the best art paper, containing descriptions and illustrations (from very fine woodcuts) of their well-known "Lancaster" patent steam traps of which, we are told, more than 70,000 have been made pistons, piston rings, packings, blocks, the "Lancaster" patent serpent coil, piston valve, metallic packings, etc., etc. A speciality of which particular mention is made is the "Lancaster" patent steam dryer. This is a combination of steam dryer and stop valve, and takes the place of the starting valve on an engine. By its adoption the dryer is got close up to the engine, thus minimising subsequent condensation between the dryer and the engine.

"Rope Driving," by Thomas Hart, maker of "Lambeth" Cotton Rope, Blackburn.—This is an illustrated booklet of thirty pages, containing a very interesting short treatise on power transmission as applied to rope gearing. On page 2 appears an excellent woodcut, showing view of an engine (installed in a Lancashire cotton mill), driving 80,000 cotton spindles. There are thirty "Lambeth" cotton ropes, 1¾ in. diameter, on the flywheel; the power is transmitted to seven pulleys in the rope race in seven separate distances, varying from 60 ft. to 93 ft. from centre to centre of shafts. To quote the author:—The first question which naturally arises is: "*In what respects do Ropes offer greater advantages than Belt or Wheel Gearing?*" The first thing to be considered is cost; cost in the first instance, the cost of renewals and repairs. Compare first with Wheel Gearing: To drive all the different storeys of a mill generally necessitates a large upright shaft, with bevel wheels on the countershaft in each storey. This, at the first, is very expensive, and often the cost of repairs and renewals amounts to a considerable sum. At one Lancashire mill, which was a few years ago driven in this way, the annual cost of repairs amounted to about £700 or £800; a very serious item. In 1890 the whole of the gearing and upright shaft was taken out, a new engine-house, and engine on the Rope transmission principle, erected. Since then repairs have been reduced to a minimum, the Ropes having run without any repairs or tightening. As an effective means of transmitting power, if we compare Wheel Gearing with Ropes, we cannot fail to notice the quiet, steady running of Ropes in marked contrast to the uneasy, uneven turning of the gearing. It is, also, much easier to keep Rope-driven shafts in line, though there is not the same necessity for doing so; with Ropes, shafts can be driven at almost any required distance apart.

The Lunkenheimer Company, Cincinnati, Ohio, U.S.A.—This catalogue contains a great variety and very complete line of brass and iron steam specialities and engineering appliances, which, with one or two exceptions, are entirely manufactured by the firm. We understand that by the end of the present year the company will occupy new factory buildings, which are likely to be unsurpassed by any similar structure of the kind. Among the principal features of the catalogue may be mentioned their brass regrinding valves of various patterns, flanged-hub brass valves, a variety of lubricators, steam injectors, water gauges, steam whistles, and whistle valves, automatic and other cylinder cocks, etc. The firm has been awarded many merit medals at exhibitions in various parts of the world, reproductions of which, in obverse and reverse, appear in the catalogue under notice.

The Crosby Steam Gauge and Valve Company, 147, Queen Victoria Street, London, E.C.—"General" Catalogue. This is in the form of a collection of leaflets, enclosed in a cover which can be adjusted for the inclusion of additional circulars as issued. The catalogue describes and illustrates amongst other fittings the Crosby Indicators, the Chapman Fullway Gate Valves, the Crosby "Pop" Safety Valves, the Crosby Water Relief Valves, various kinds of gauges, sight feed lubricators, pressure recorders, etc. Wherever possible, drawings of the various fittings, and also weights, have been supplied. In most cases prices are also quoted. One speciality, the Mason Reducing Valve, is worthy of special mention. This valve automatically reduces boiler pressure for steam-heating coils, dry rooms, paper-making machinery, slashers, dye-kettles, and all places where it is desirable to use lower boiler pressure than that of the boiler.

The Joseph Dixon Crucible Company, of Jersey City, U.S.A. An excellent little *brochure*, containing a general description, with half-tone illustrations, of the principal graphite productions of this company, with index. It is explained that, owing to market conditions, no prices are given, but that a current price list will be supplied on application. The principal manufactures are plumbago retorts, stirrer-holders, graphite stirrers, graphite boxes and covers, brazing crucibles, phosphorisers, and anti-flux graphite, for brazing, plumbago facings of various kinds, graphited lubricants (oils and greasers), a silica-graphite paint, and many others. Both the half-tone illustrations and printing are of a high-class nature, and in general design and arrangement the catalogue leaves little to be desired.

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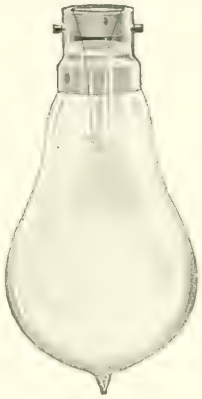

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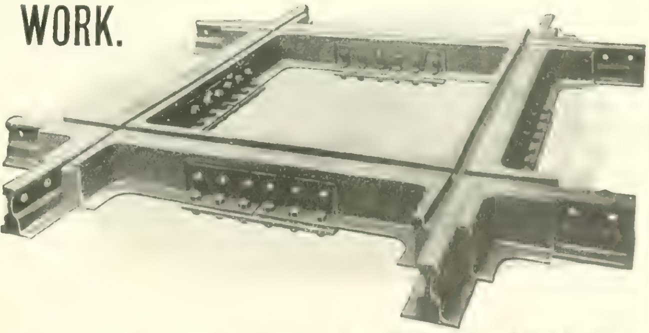

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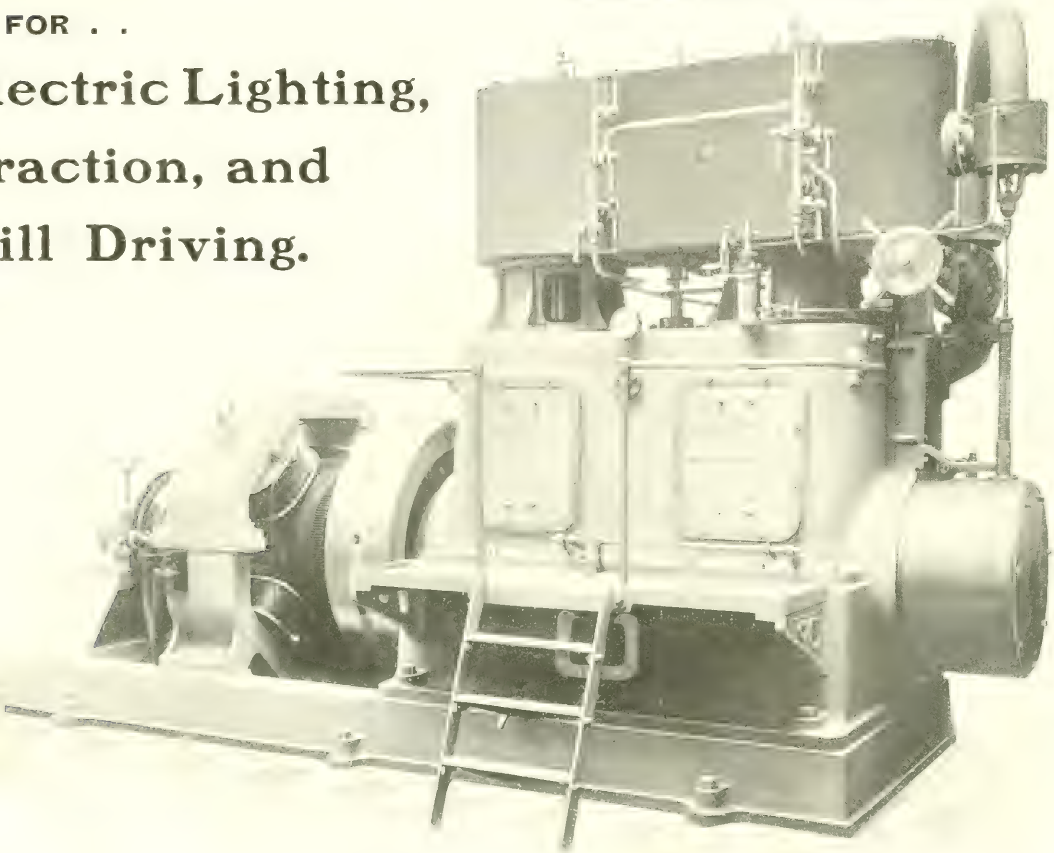

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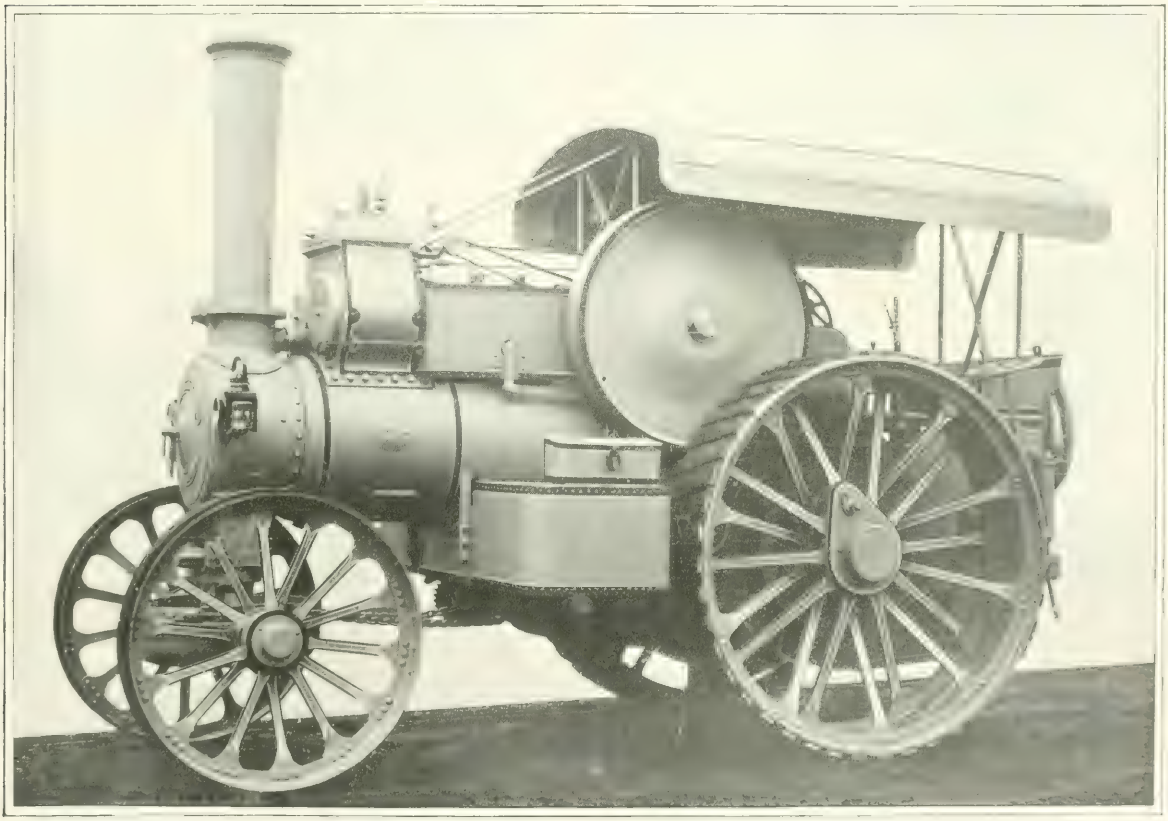

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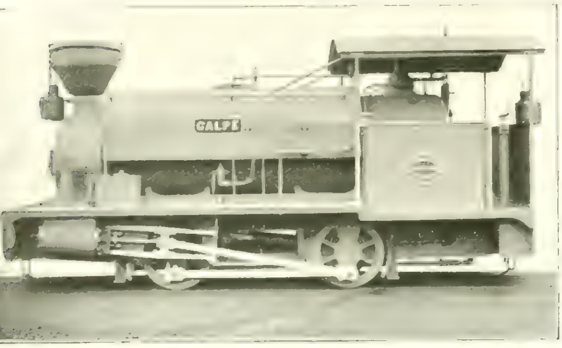

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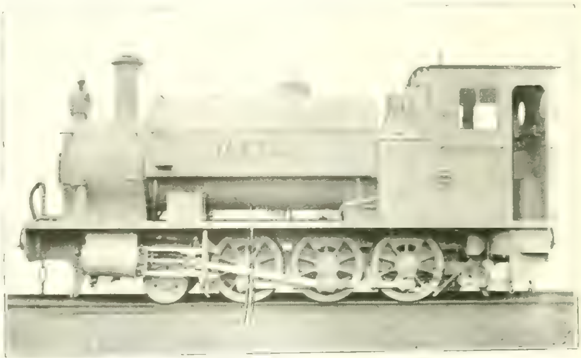

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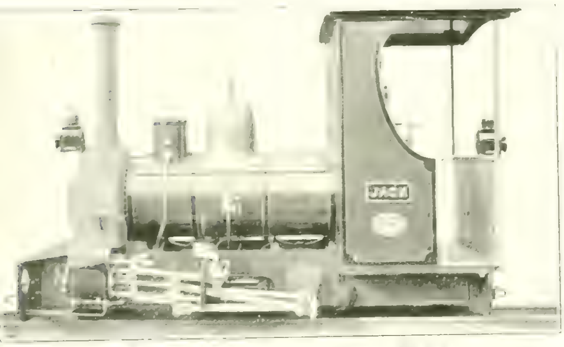

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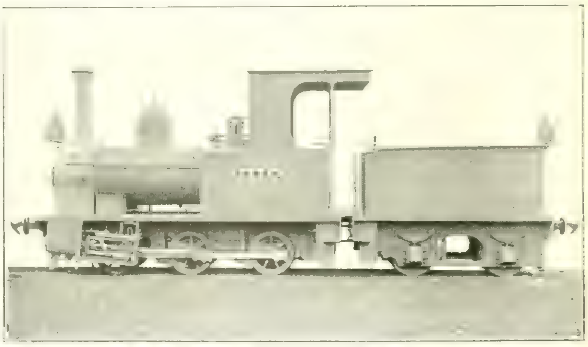

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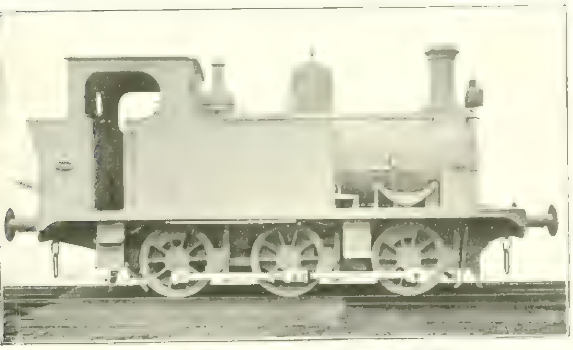

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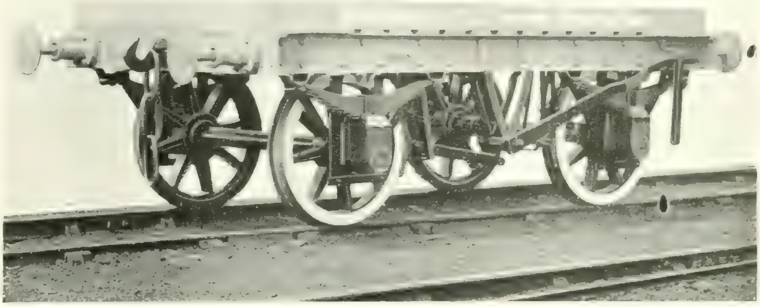

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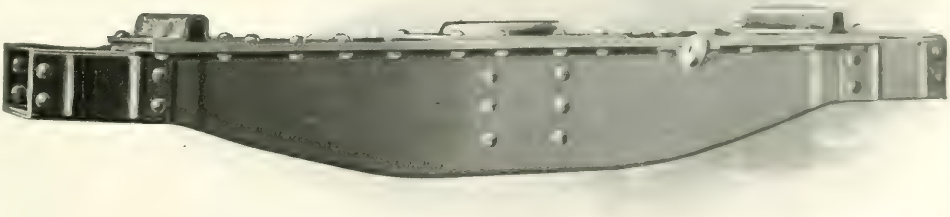

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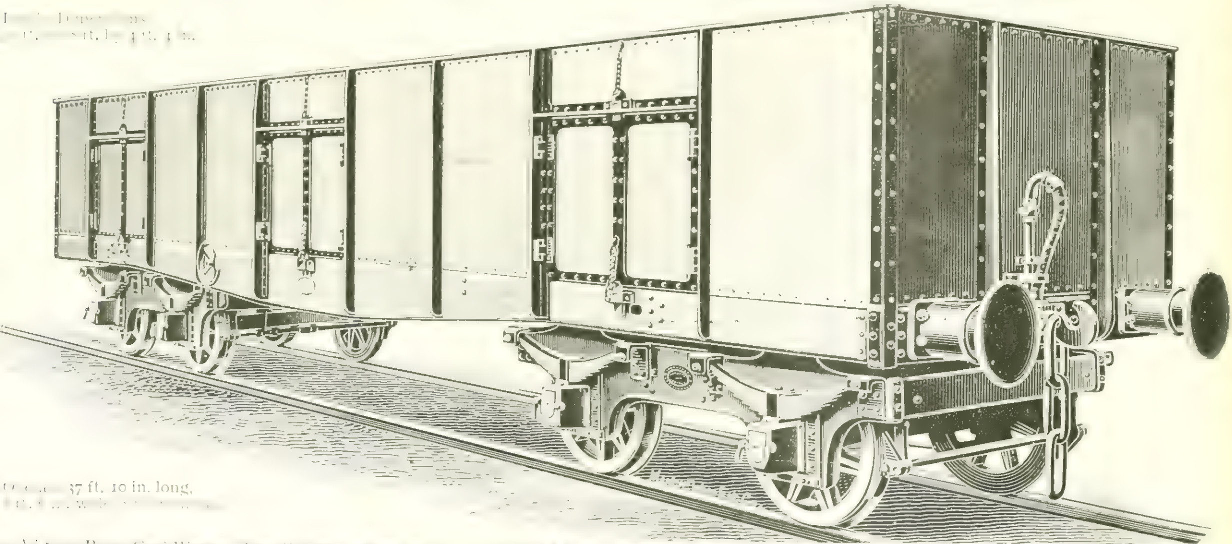
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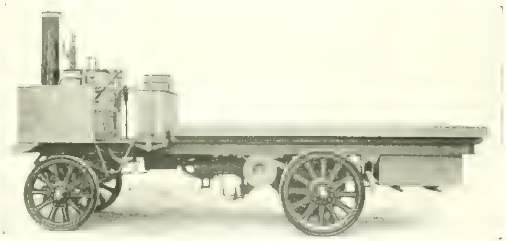

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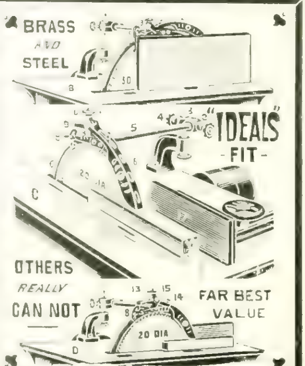

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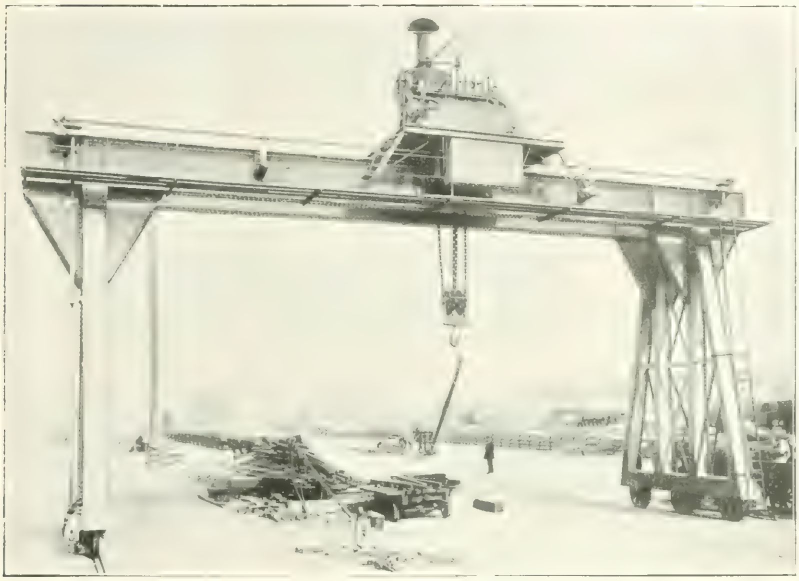

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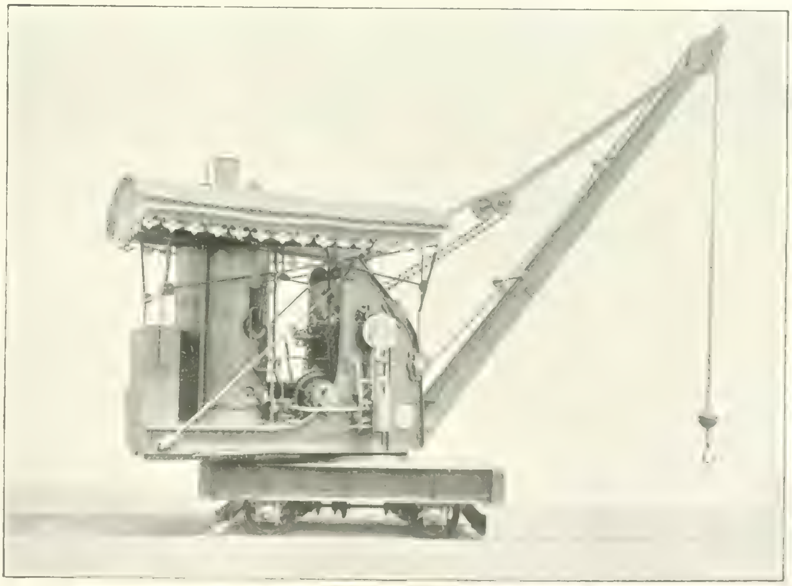

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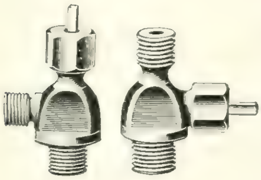

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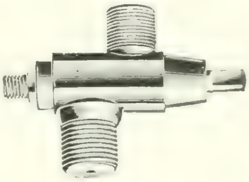

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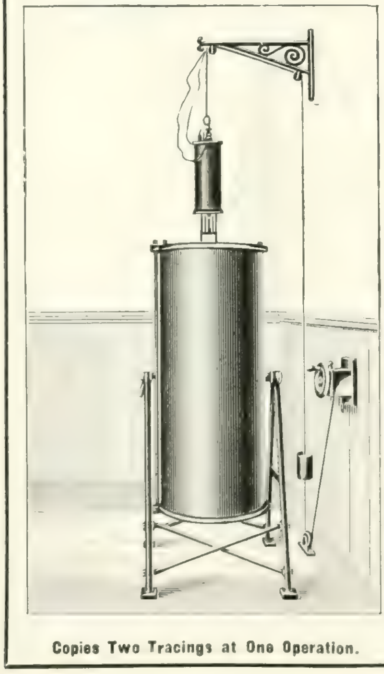

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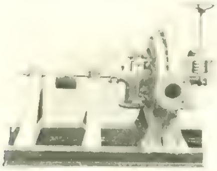

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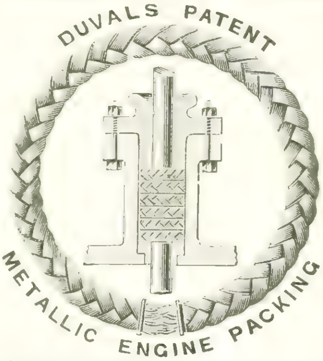

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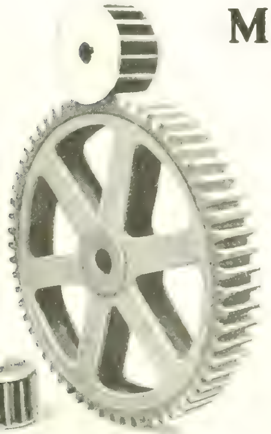

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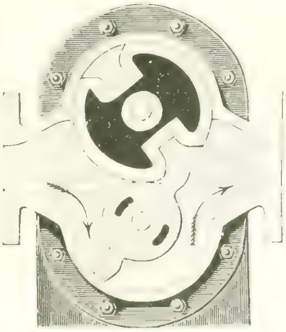

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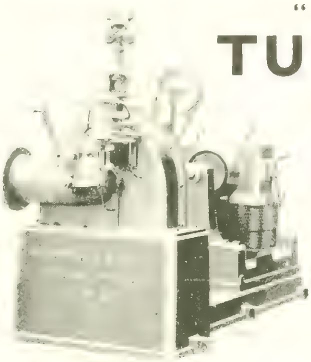

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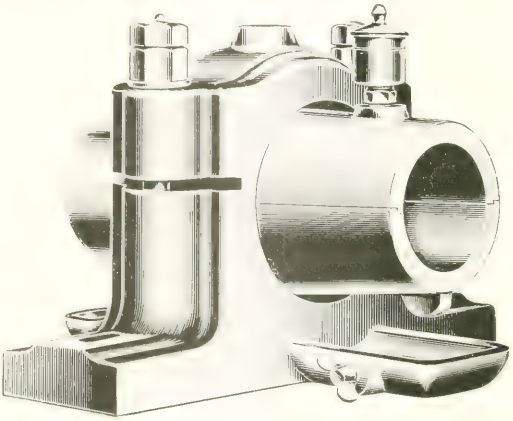

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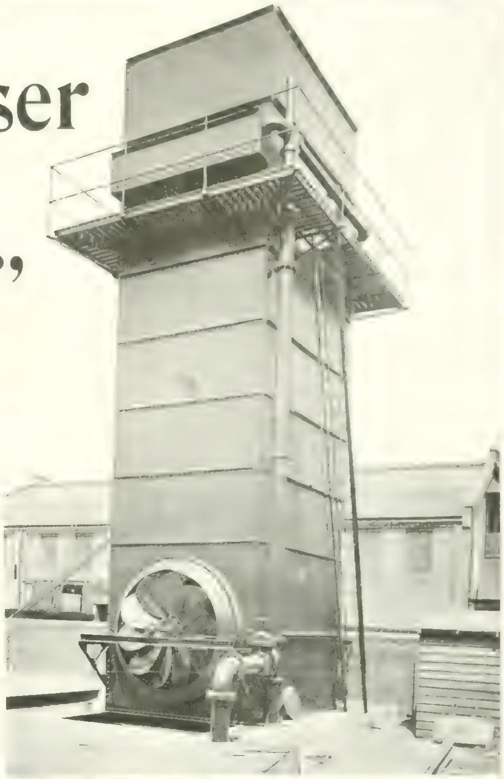

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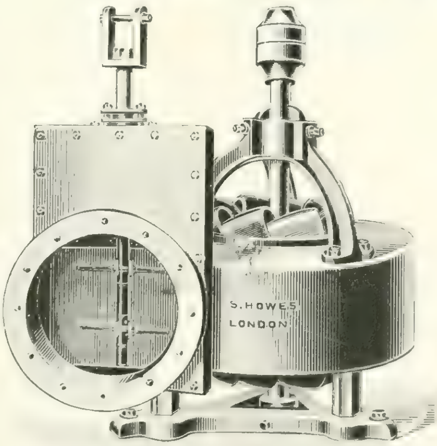

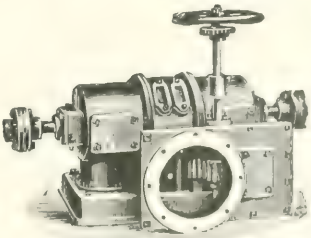

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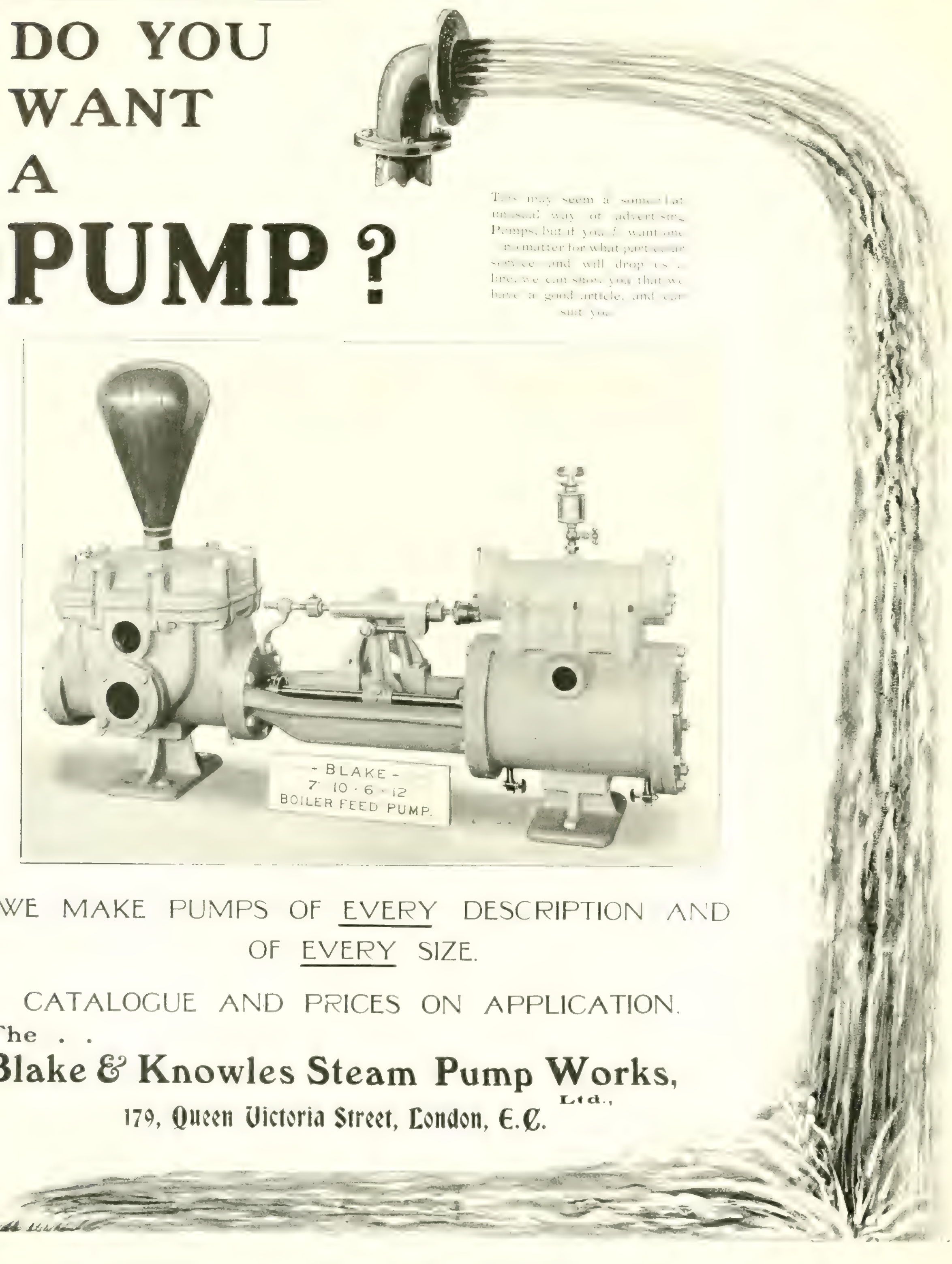

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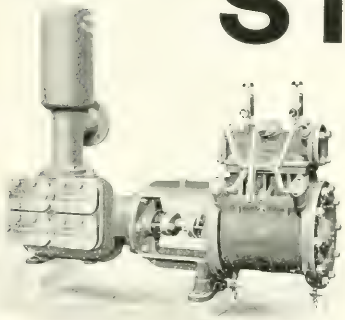

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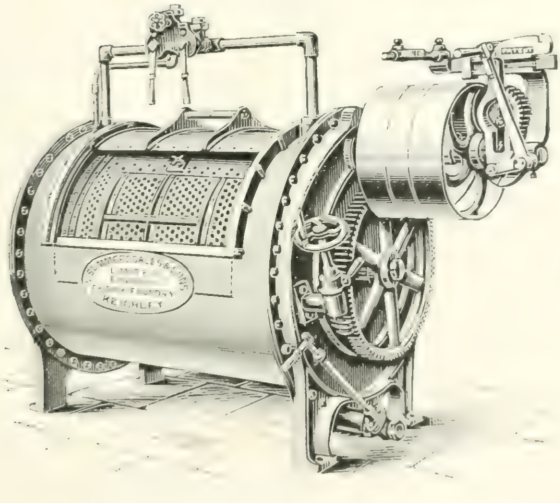
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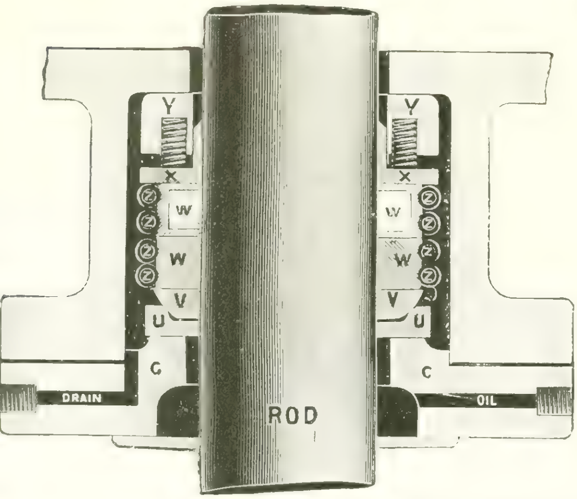

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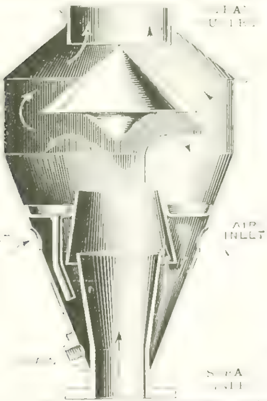

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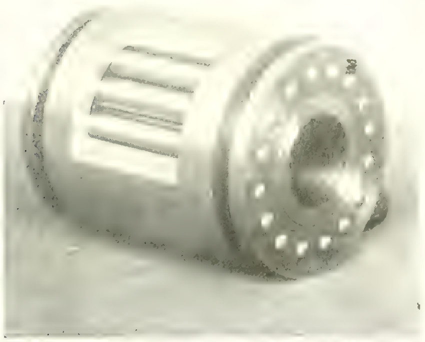
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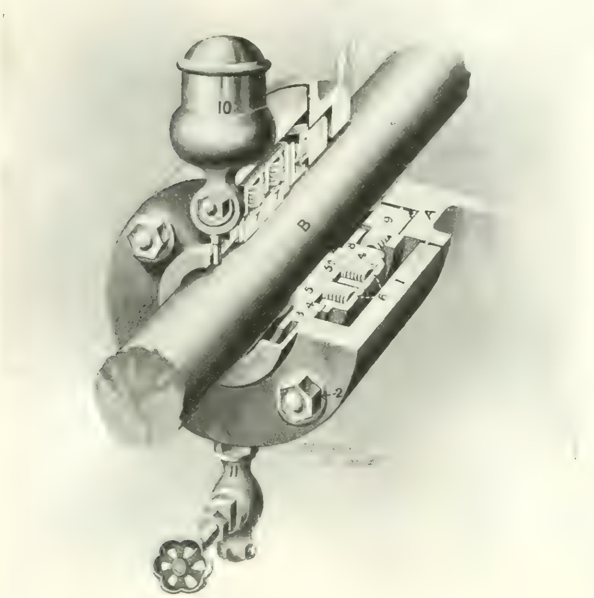

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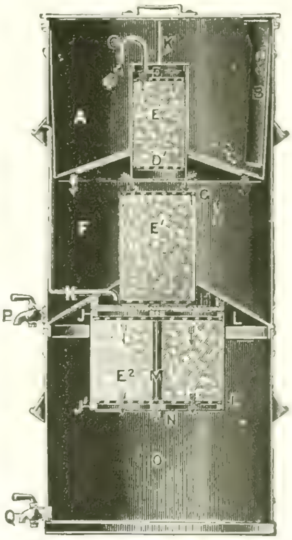

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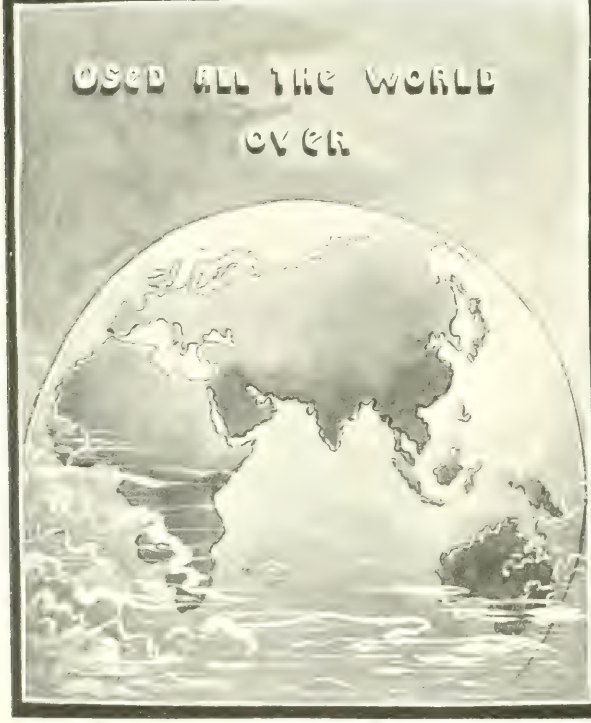
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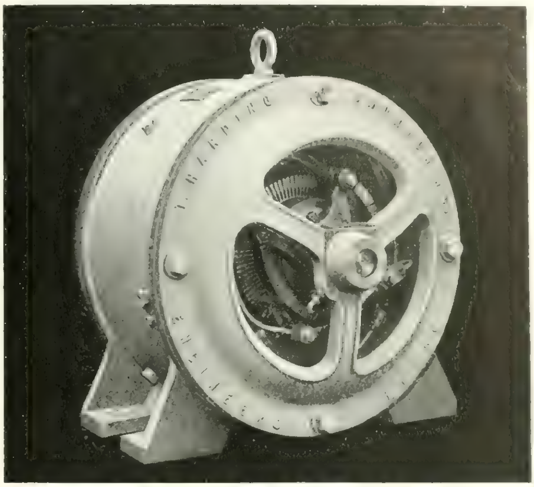

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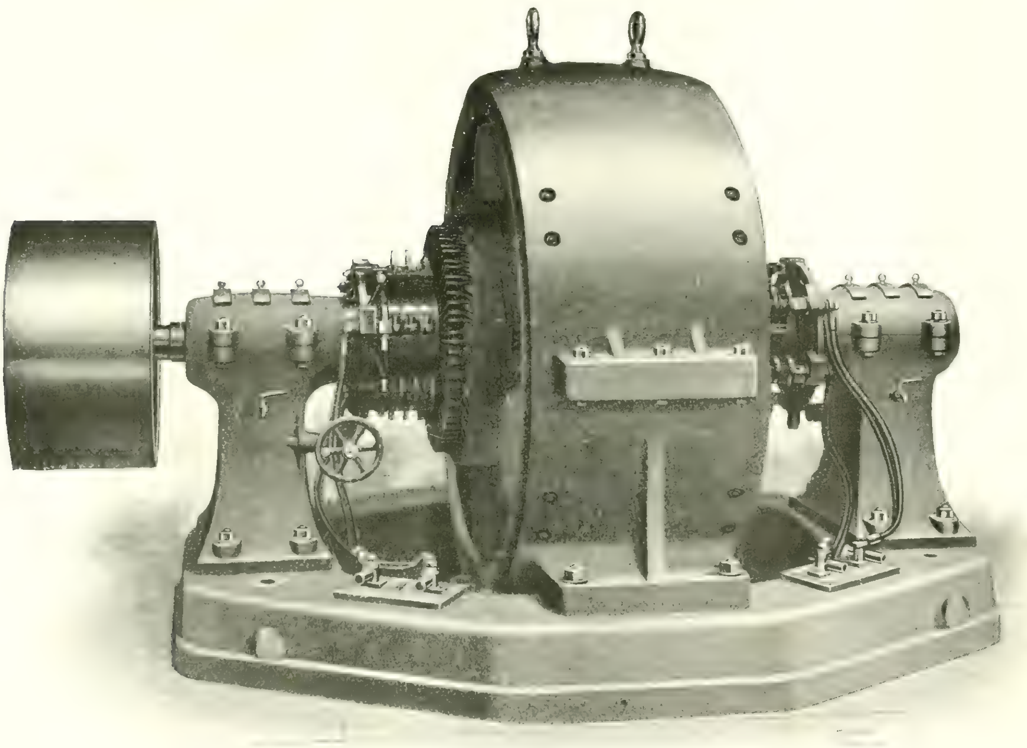

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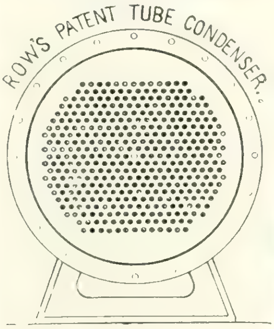

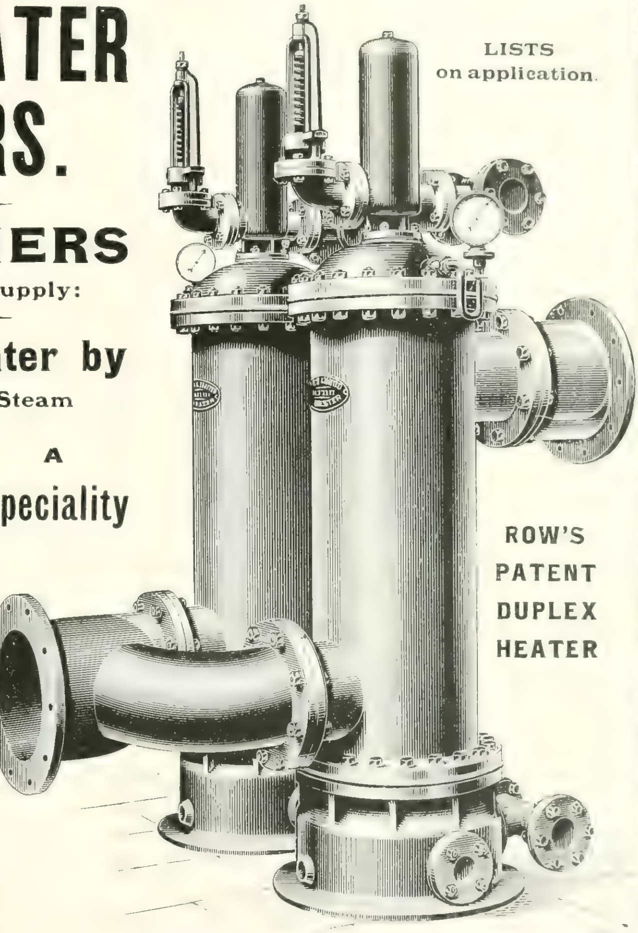

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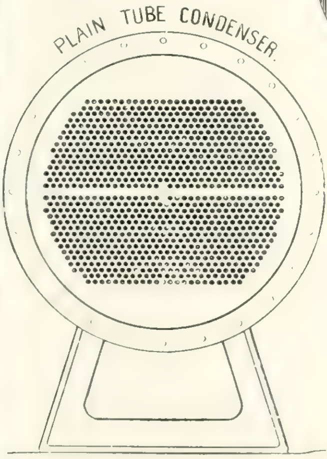

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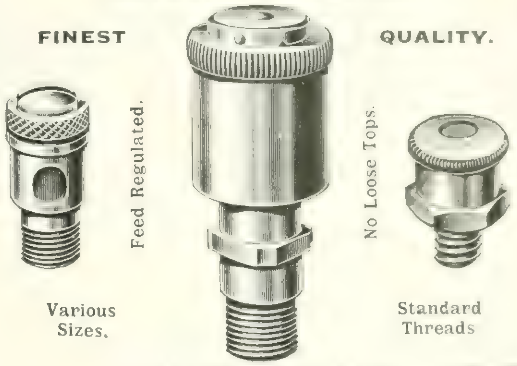
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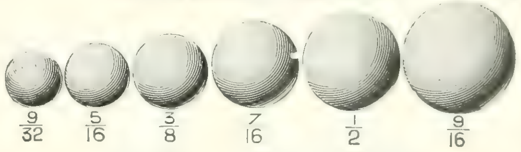

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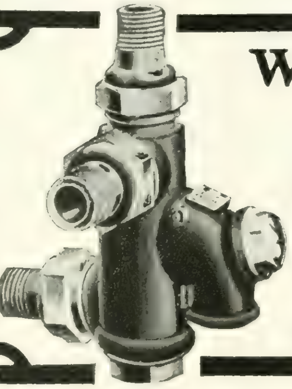

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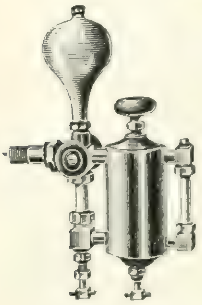

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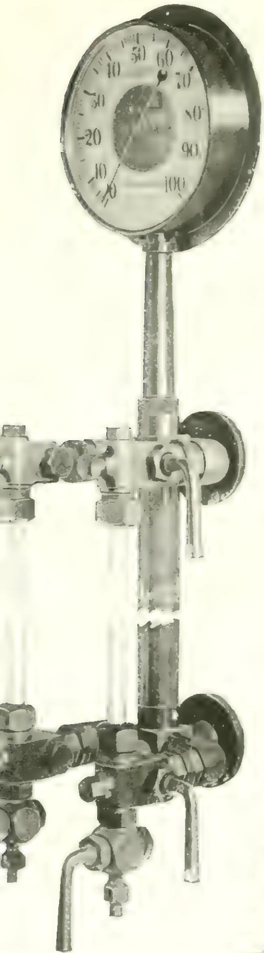

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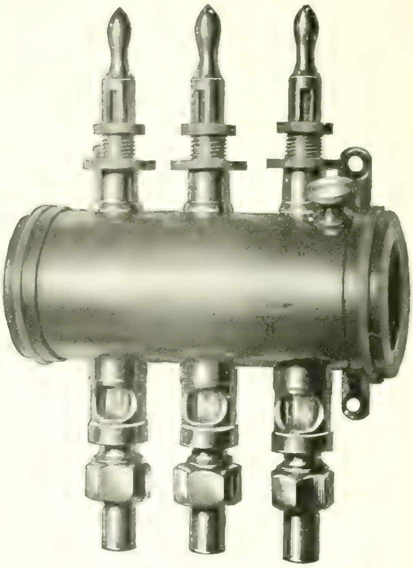

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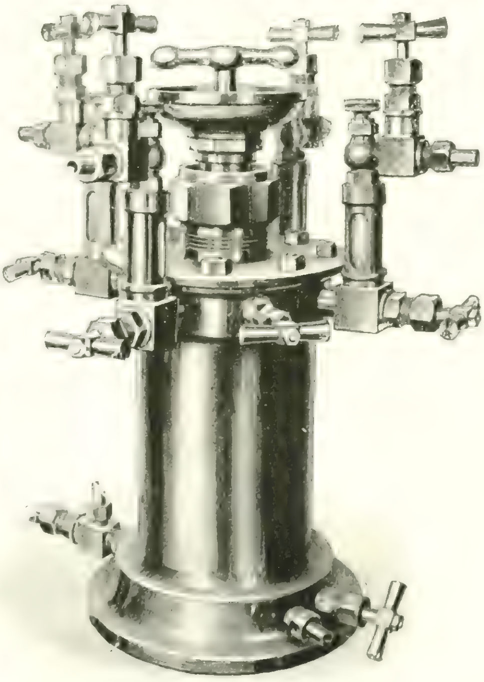

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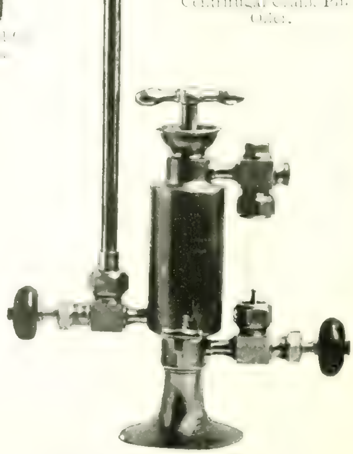

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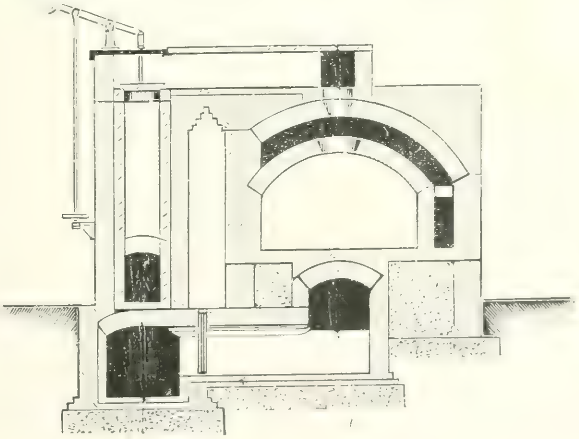

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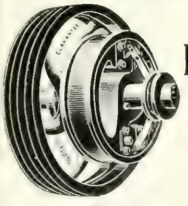

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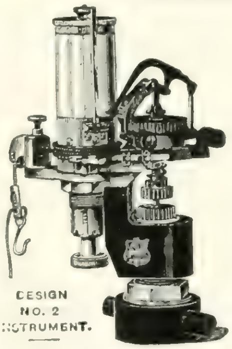

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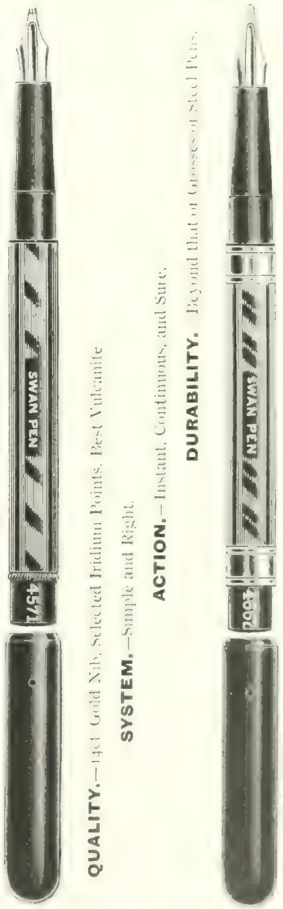

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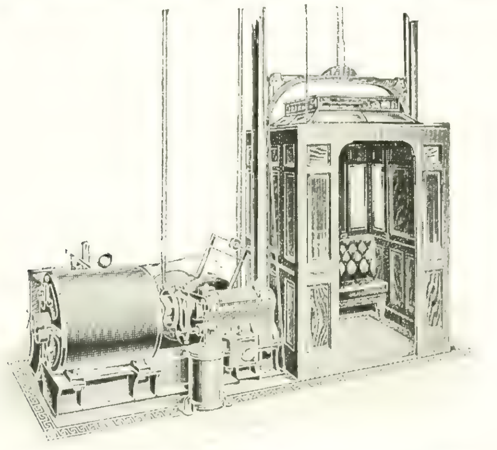

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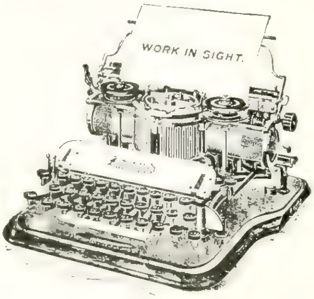
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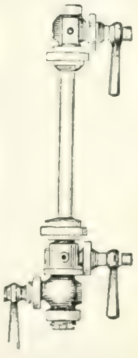

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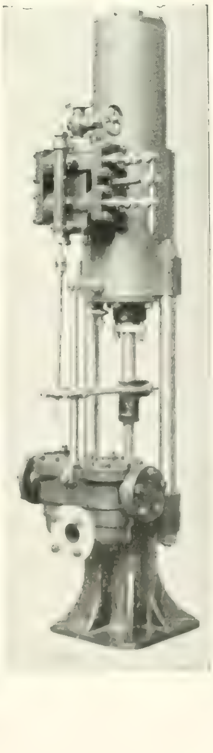

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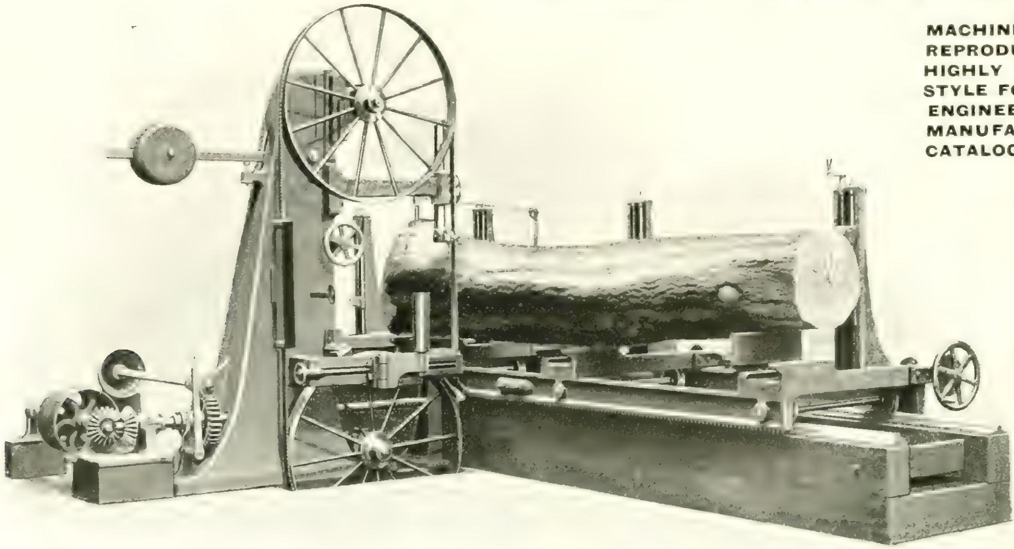

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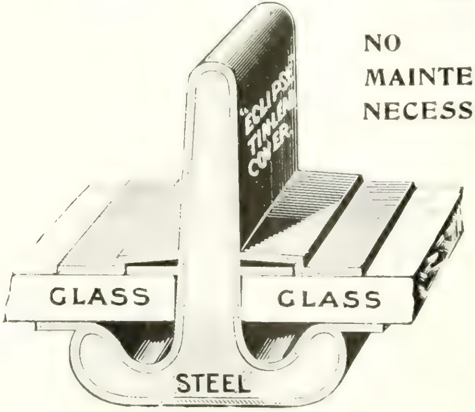

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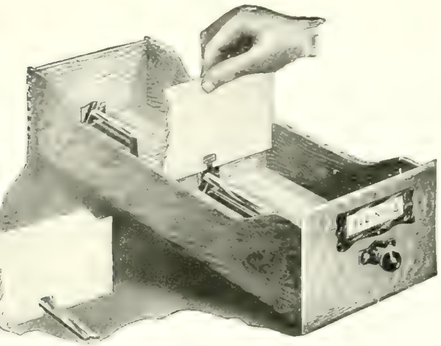

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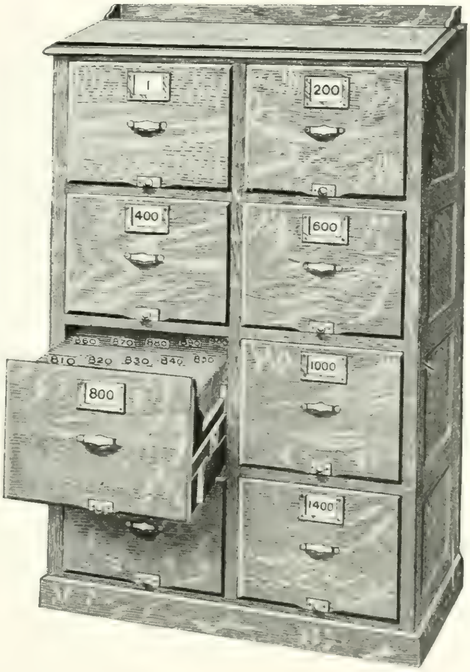

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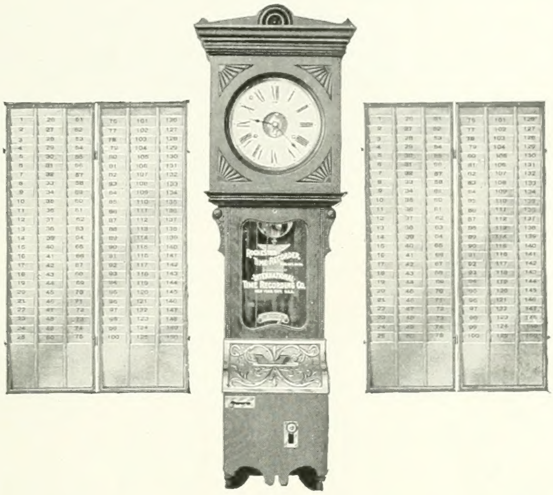

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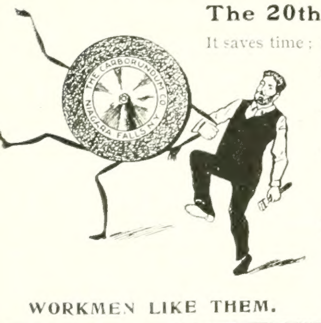

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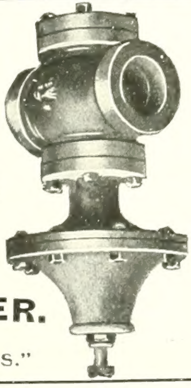

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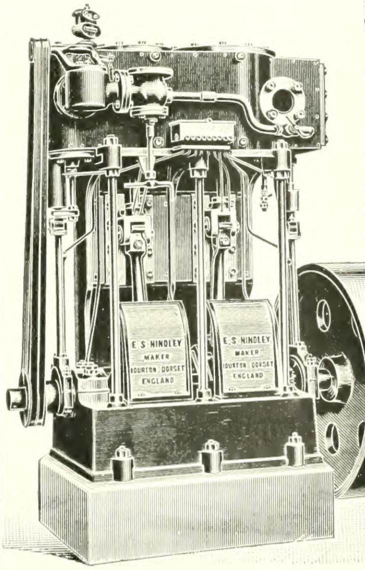

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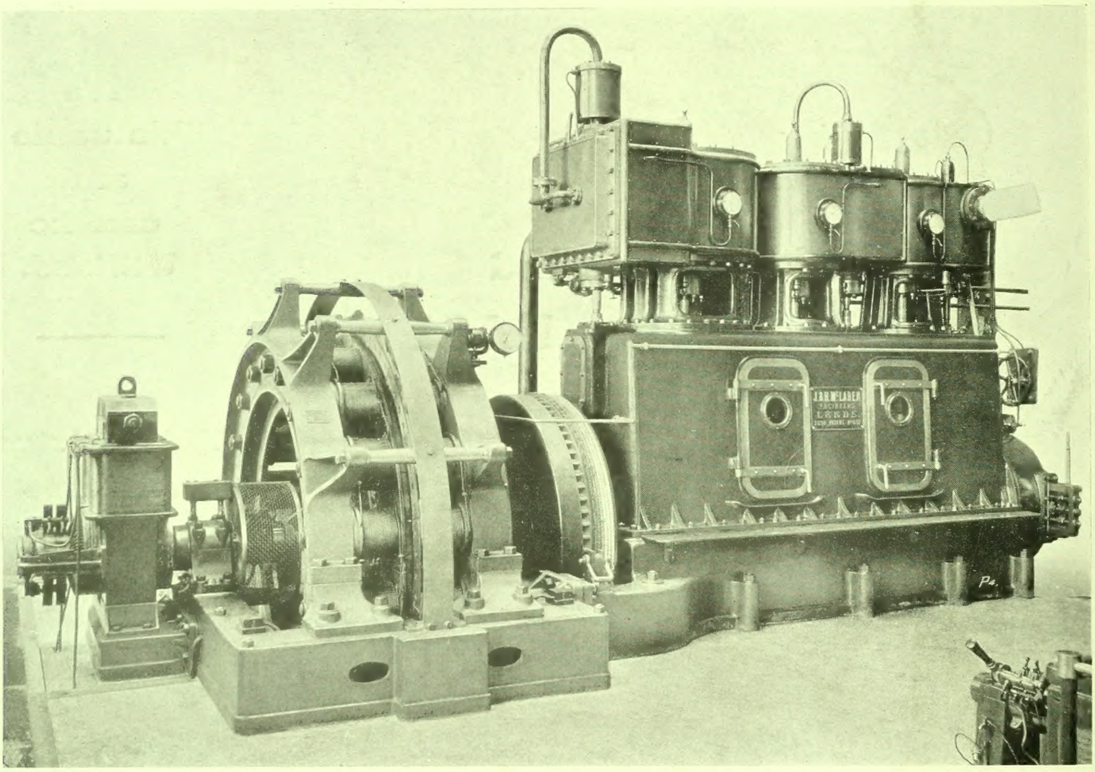

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